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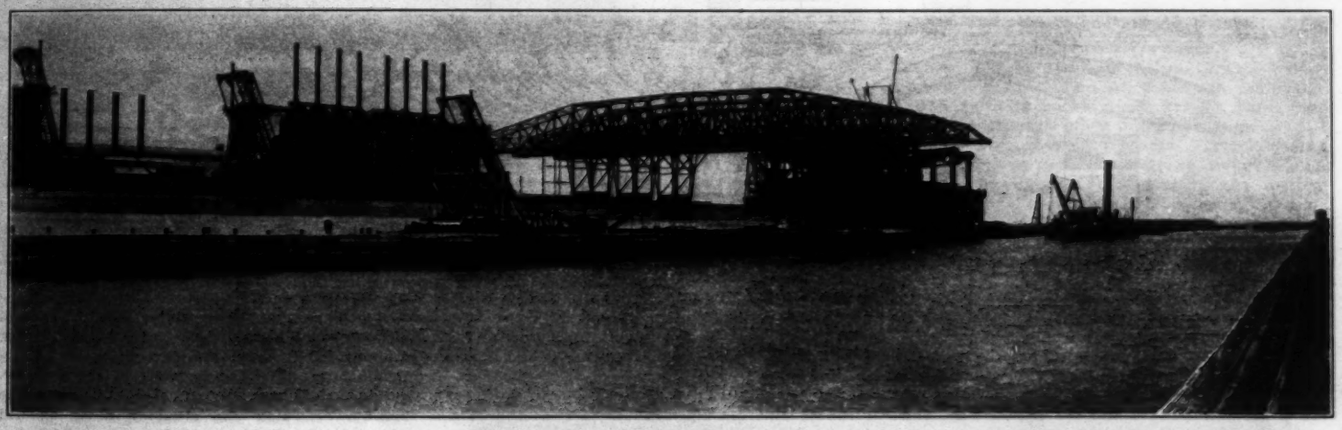
The Great Steel Works of the Indiana Steel Co. at Gary, Ind.

About four years ago the United States Steel Corporation decided upon the establishment of a new steel manufacturing plant of exceptional size, owing to the great increase in its business, and to the fact that all of its existing plants were in congested centers where extensions for the necessary increase in capacity were impracticable. A location was selected in Indiana on the south shore of Lake Michigan (where ore could be delivered directly by steamers), about 25 miles south of Chicago. The company purchased an area of over 9,000 acres, having a water front of seven miles. About 1,000 acres of this, with a water front of two miles, forms the site of the present works. The location is in a sandy waste, which was quite uninhabited. With a site of this kind there were no limitations due to high cost of land or to interference with neighboring industries (as in the case of plants built in the outskirts of large cities), and the designers had a free hand in planning the layout to the best advantage for large capacity, combined with high efficiency and economy of operation.



PANORAMIC VIEW SHOWING THE ORE UNLOADERS, ORE HANDLING BRIDGES AND ONE GROUP OF BLAST FURNACES AND HOT-BLAST STOVES; INDIANA STEEL CO., GARY, IND.

Four special features are: (1) the plant is to produce open-hearth steel only; (2) the blast furnace gas is utilized on a large scale; (3) electric power is used very extensively throughout the plant; (4) the roll trains of the various mills are driven directly by or geared to electric motors. For the construction of this plant, a separate company was organized under the name of the Indiana Steel Co.

The complete plant will comprise the following principal parts: (1) ore-unloading machines and ore storage yard; (2) 16 blast furnaces of 450 tons daily capacity each, in four batteries, with hot-blast stoves and gas washers; (3) blowing plant, with 32 blowers driven by gas engines using blast-furnace gas; (4) a pig-casting plant; (5) six open-hearth steel plants, each with 14 basic furnaces of 60 tons daily capacity; (6) the largest rail mill in the world, having the special feature of electric drive for all roll trains, and having a capacity of 4,000 tons of rails per 24 hours; (7) an electrically operated billet mill; (8) a universal plate mill (rolling plates up to 60 ins. in width) and a sheared plate mill; (9) six merchant mills, one 18-in., one 14-in., two 12-in. and two 10-in.; (10) an axle mill; (11) extensive repair shops; (12) an electric power station. A structural mill is proposed, but nothing has been decided in regard to it. A general plan of the works is given in Fig. 2, and shows the portions completed, under construction, and not yet started.

In June, 1909, the condition of the work was as follows: (1) the slip for ore steamers was finished, and half of the ore handling plant was in operation; (2) four of the blast furnaces were in service and four more were under construction; (3) eight gas-driven blowing engines were in service; (4) the pig-casting plant was completed to half its ultimate capacity; (5) two of the open-hearth plants were built and nine of the furnaces in operation, a third plant was being erected; (6) the rail mill was in operation, and the soaking pits for the rail mill and the billet mill were completed; (7) the billet mill and the universal plate mill were under construction; (8) the foundations of the axle mill were under construction, and the 18-in. and 14-in. merchant mills were being erected; (9) the electric power station was nearly finished; (10) the repair shops were completed and in use.

The first stake for the layout of the plant was driven March 12, 1906. The first cargo of ore was delivered and unloaded on July 23, 1908. The first blast furnace was blown in on Dec. 21, 1908, and the first rail was rolled on Feb. 17, 1909.

Ore Unloading and Handling.

For the ore steamers a canal or slip has been excavated, extending south about 5,000 ft. from the new shore line (which is 2,000 ft. beyond the original shore line). The entrance will be protected by a breakwater extending out into the lake, and this is under construction. At present the slip is protected against the entrance of waves from the open lake by two bulkheads 800 ft. apart, extending partly across the channel from opposite sides of the slip, like baffle plates. The first leaves an opening of 117 ft. at one side of the channel, and the other leaves a 90-ft. opening at the other side. This temporary arrangement, with the navigation lights, is shown in Fig. 3. The canal has 22 ft. of water, and is 250 ft. wide, the width being increased to 750 ft. at the south end, so as to form a turning basin for the steamers.

The west side of the canal is formed by a concrete retaining wall, beyond which is a space for the ore unloaders, ore-handling bridges, and ore stock piles. There are five unloading machines (10 for the completed plant), of the Hulett type (Engineering News, Aug. 3, 1905, and Nov. 22, 1906). Each has a 10-ton bucket on a vertical arm which is raised and lowered by a walking beam. The bucket delivers its load to a conveyor car which runs back to the rear of the machine and discharges the ore into a trough along the edge of the stock yard or into hoppers on the machine, from which the ore can be delivered into cars. The machines are carried on two tracks 62 ft. apart, and span two railway tracks laid along the dock. They are operated by electricity. Each machine weighs about 450 tons and requires only three men to handle it. The machines have been unloading

ore at the rate of 300 tons per hour for each machine. The panoramic view, p. 161, shows the entrance canal (with its concrete wall on the left side), the ore-unloading machines, the ore-handling bridges (which travel along two high concrete walls), and one pair of the blast furnaces with their charging hoists, hot-stoves, dust catchers and gas washers.

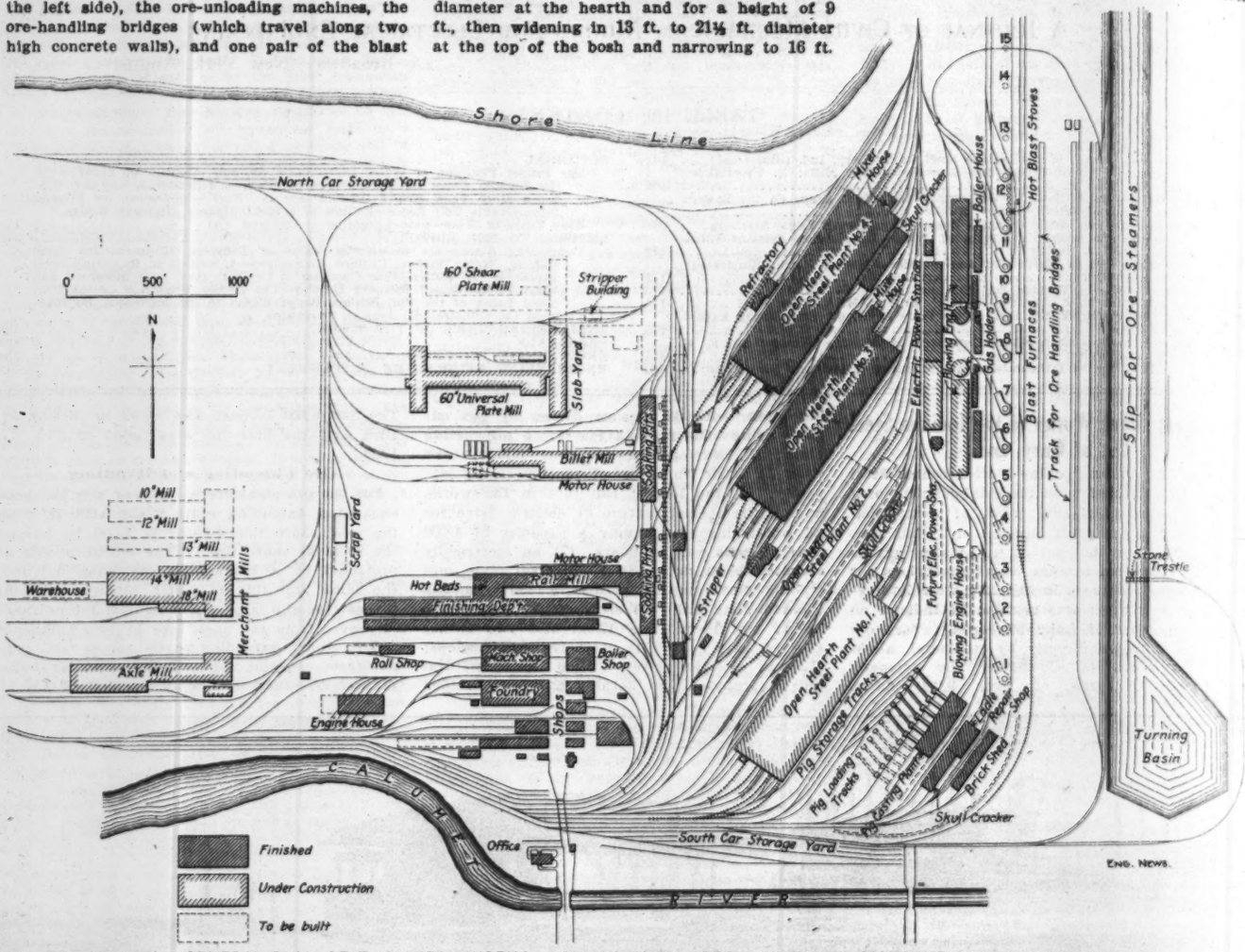


FIG. 2. GENERAL PLAN OF THE STEEL WORKS, ROLLING MILLS, ETC., OF THE INDIANA STEEL CO. AT GARY, IND.

The concrete trough into which the conveyor car delivers the ore is under the cantilever ends of five traveling conveyor bridges of the Hoover & Mason type, and five more will be added for the complete plant. These are 495 ft. long, and each is carried by two towers 187 ft. apart, having two cantilever ends of 154 ft. Each tower is carried by 16 wheels traveling on rails laid upon concrete walls 25 ft. high, which divide the storage spaces into three sections. The bridges are unusually high, being 85 ft. above the floor of the stock yard. Each bridge has a 15-ton grab bucket which rides on a track on the lower chord, and is operated by a cable in the usual way, all movements being effected by electric motors. The conveyors take the ore from the trough and distribute it on the stock piles, and also load the blast furnace cars with ore from the stock piles.

The storage capacity of the yard is about 1,200 tons per ft. of length. Its present length is 2,500 ft., but provision is made for its extension to a total of 4,000 ft. The storage capacity is sufficient for normal operation of the works during a period of six months, and provides for a supply during the winter months when lake navigation is suspended. There is a coke storage yard some distance from the works, equipped with Hamilton coke-handling machines, as described in our issue of July 16, 1908.

Blast Furnaces.

The 16 blast furnaces (eight now built) are arranged in a straight line parallel with the stock yard; they are alternately 220 ft. and 300 ft. apart, with eight hot-blast stoves in each of the 300-ft. spaces. Each furnace is served by four stoves. The blast furnaces are 15 ft. diameter at the hearth and for a height of 9 ft., then widening in 13 ft. to 21½ ft. diameter at the top of the bosh and narrowing to 16 ft. at the top of the furnace lining, which is 88 ft. above the tapping notch. They are rated at a capacity of 450 tons per day for each furnace.

One of the groups of blast furnaces and stoves is shown on p. 161. The erection methods employed by the Riter & Conley Co. for the blast furnaces and hot-blast stoves is shown in Fig. 4. A rectangular steel tower carries two lattice booms, and also two cantilever frames with hoisting booms on the outer ends.

Between the ore yard and the blast furnaces are two parallel rows of elevated storage bins 2,200 ft. long, one row for coke and the other for limestone and ore. The bins have a capacity of 4, 9 and 13 tons per lin. ft. for these materials respectively. The ore is delivered by two 60-ton electric transfer cars which travel on a track of 6 ft. 3 ins. gage laid along the top of the bins and are loaded by the buckets of the ore bridges. The coke and limestone are brought in by rail, the cars being pushed up an incline to three tracks laid over the bins.

Each 14 ft. panel of the ore and limestone bins has two bottom spouts, and each panel of the coke bins has a single spout. All the spouts are fitted with electrically operated gates. From these the materials are delivered into electric transfer cars, each having a weighing hopper of 120 cu. ft. capacity. The transfer cars deliver the materials to the furnace skips, each furnace having a pair of skips riding on an inclined skipway which has an incline of 60° and a length of about 163 ft. from the skip pit to the charging platform. The trip is made in about 60 sec. The operator has only to start the skip; the running, retarding and stopping being effected automatically. The skip load averages 7,000 lbs. of ore, 6,000 lbs. of limestone, or 3,600 lbs. of coke.

To reduce the breakage of coke by handling from the railway car to the bin, and again from the bin to the transfer car, each furnace has a coke storage bin into which the railway cars may discharge their loads and from which the coke may be delivered directly to the furnace

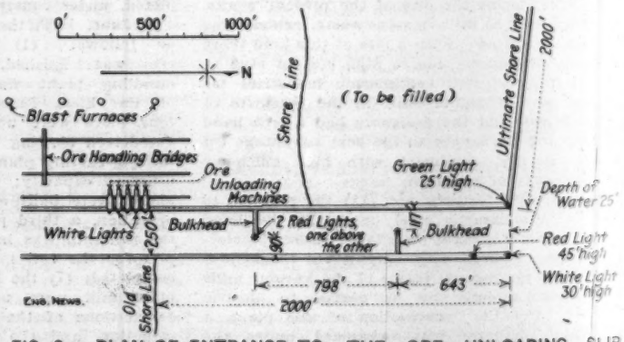


FIG. 3. PLAN OF ENTRANCE TO THE ORE UNLOADING SLIP, SHOWING THE NAVIGATION LIGHTS AND THE TEMPORARY BULKHEADS TO EXCLUDE WAVES.

skip. These bins are heated by steam coils to prevent any trouble and delay due to the freezing of the coke.

Pig-Casting Machines.

In ordinary working, the molten metal from the blast furnaces is delivered to the open-hearth furnaces. At each blast furnace, however, there is a pig-casting house, extending at an angle of 22½° with the line of furnaces in order to avoid unnecessarily wide spacing between them. For disposing of the metal on Sundays and holidays, when the open-hearth furnaces are not working, there is a special plant having six Heyl & Patterson pig-casting machines to serve the present blast furnaces. This will be increased to 11, when the 16 furnaces are in use.

FIG. 4. ERECTION TOWER USED FOR BLAST FURNACES AND HOT-BLAST STOVES.

This plant, with one of the casting machines, is shown in Fig. 5. The metal is brought to it in 40-ton ladle cars and the ladle is set with its trunnions resting in the hinged frames at (A), Fig. 5. The hook of the wall crane is then attached to a ring bolt in the cross piece (B), and the frame tilted, revolving on the pins (C) (C). The metal from the ladle flows into a runner (D) which delivers it to the continuous chains of traveling molds (E) (E). These are 115 ft. long, and deliver the pigs to conveyors which carry them for 100 ft. through the tank or cooling trough (F), at the end of which the conveyors rise to a tower (G) having a chute by which the pigs are delivered into railway cars. There is a separate loading track for each machine, and these are gravity tracks with a grade of 1.25%.

Near this plant is the "skull cracker" for cracking the shells or skulls of cooled metal from the ladles. This has a steel runway with a 40-ton crane which drops a 6-ton iron ball from a height of 60 ft. The skulls and the ball or "cracker" are handled by Cutler-Hammer hoisting magnets.

Blowing Plant.

The blowing engines for the present blast furnaces are contained in two brick and concrete buildings 600 ft. and 500 ft. long and 104 ft. wide. Each contains ten blowers of the Slick type, eight driven by gas engines and two driven by steam engines. The 600-ft. building also contains the high-pressure pumping plant which serves the hydraulic machinery. The gas and blowing cylinders are placed tandem, each engine having a 42-in. gas cylinder and 72-in. blowing cylinder, with 54-in. stroke. The engines are rated at 2,500 HP. each, and are run at a speed of 60 r. p. m. Each will deliver 33,000 cu. ft. of free air per minute at the normal pressure of 18 lbs., or 28,000 cu. ft. per minute at the maximum delivery pressure of 30 lbs. Compressed air at 200 lbs. pressure is used for starting. This is stored in a 30-in. tank and is delivered direct to each engine by pipes.

The gas engines were built by the Allis-Chalmers Co. and the Westinghouse Electric & Mfg. Co. The two steam blowing engines built by the Tod Co. are of the cross-compound type, with steam cylinders 44 ins. and 84 ins. diameter and air cylinders 90 ins. diameter, all of 72 ins. stroke. With 150 lbs. steam pressure, 26 ins. vacuum and a speed of 40 r. p. m., each will deliver 40,000 cu. ft. of free air per minute. Opposite each air cylinder there is an air intake opening in the wall of the building, the opening being fitted with louvres and wire screens. Fig. 6 is a view in one of the blowing-engine houses.

Each of the blast furnaces will require about 44,000 cu. ft. of air per minute. The normal blast pressure is 18 lbs. per sq. in., with provision for increase to 25 or 30 lbs. in case the furnace burden should show a tendency to mass or choke. Under test, some of the blowing units have been operated at a delivery pressure as high as 39 lbs. When casting, or when the blast is being changed from one group of stoves to another, the blast pressure drops to about 5 lbs.

Furnace Gas.

The amount of gas from the eight blast furnaces is about 22,450,000 cu. ft. per hour. It is estimated that about 30% of this gas is required in the hot stoves, 7.5% for the boilers, 15% for the blowing engines, and 45% for the engines of electric power station. About 2.5% is lost in the gas washers. The gas coming from the furnace is passed through dust catchers and a preliminary washing plant which removes the greater part of the heavier foreign matter. The gas to be used in the hot-blast stoves and under the boilers is given no further treatment, but the gas for use as fuel in the engines is passed through a secondary washing plant. The primary washers are arranged with a battery of three washers for each pair of blast furnaces. One washer has a capacity sufficient to take care of the gas from one blast furnace, or nearly 50,000 cu. ft. per min. The secondary washers have each a capacity of about 15,000 cu. ft. per min., and are arranged in batteries of eight units. The primary and secondary washing plants have capacities of 150,000 and 120,000 cu. ft. per min. respectively. The purified gas for the engines averages 90 B. T. U. per cu. ft. It is stored in a gas-holder of 200,000 cu. ft. capacity, from which it goes to the blowing and power engines.

As the furnaces are of the closed-top type, all the large gas piping is designed to stand a maximum pressure of 35 lbs. per sq. in. in case of explosions of dust or gas in the furnace. Relief vents with water seals are provided at different points to reduce these pressures and avoid injury to the washers and other apparatus.

Open-Hearth Furnaces.

There will be six open-hearth furnace buildings eventually. Two of these are completed and a third is under construction. These are parallel with each other but at an angle of 35° with the line of blast furnaces. This arrangement effects an economy in space occupied, and reduces the distance for carrying the molten metal from the furnaces. This metal is con-

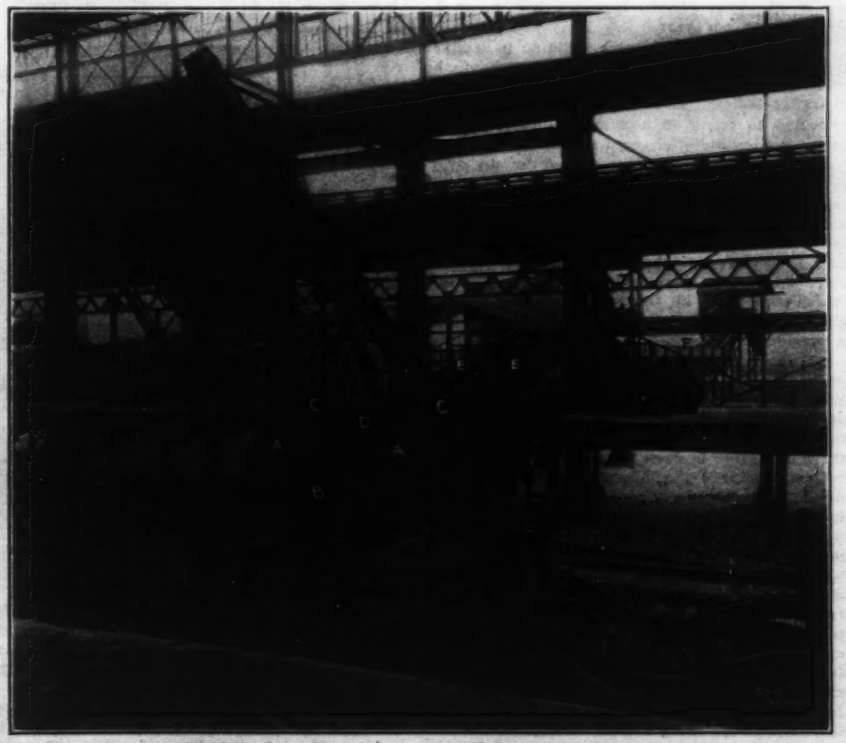


FIG. 5. PIG-CASTING PLANT OF THE INDIANA STEEL CO.

veyed in 40-ton ladle cars. The buildings are of steel frame construction, 1,190 × 193 ft. and are arranged in pairs. The central span of 83 ft. 6 ins. covers the furnaces and charging floor. The rear of this floor extends under a 45-ft. side span and has three tracks for cars carrying the charging boxes with steel scrap for the furnaces. On the other side is a span of 64 ft. 9 ins.

FIG. 6. BLOWING ENGINES DRIVEN BY GAS ENGINES USING BLAST FURNACE GAS; INDIANA STEEL CO., GARY, IND.

covering the pouring floor. The scrap in the stock yard is handled by electro-magnetic hoists. The open-hearth plants Nos. 3 and 4 are shown in Fig. 7, which gives an idea of their size and general design.

The open-hearth furnaces are of the type generally used in the modern basic process and are 16 × 40 ft. at the hearth, with a capacity of 60 tons. The doors are operated by hydraulic power, but it is expected to use electric power for those of the furnaces yet to be built.

The four plants of 56 open-hearth furnaces already provided for will have an output capacity of about 225,000 tons per month, or 2,700,000 tons per year.

At the end of each furnace building is a mixer building, containing two 300-ton mixers of the rocking type, which deliver their contents into charging ladles. This larger mixer capacity is expected to result in a very uniform character of the molten metal charged into the open-hearth furnaces. The mixers are served by an overhead crane having a 75-ton hoist for the 40-ton ladles carrying metal from the blast furnaces, and a 15-ton auxiliary hoist for tilting these ladles. The 60-ton charging ladles are conveyed part of the way to the open-hearth furnaces on electric transfer cars, and a 75-ton traveling crane then picks up the ladle from the car and charges the molten iron into the furnace through a runner.

On the tapping or pouring side of the furnaces, shown in Fig. 8, the metal is poured into 80-ton or 100-ton ladles. These are set in place at the furnace and removed to the ingot pouring stands by 125-ton overhead cranes, of which there are three in each building. The ladles are set on standards or supports in front of the furnaces, these supports having seats or bearings to receive the trunnions of the ladles. In the buildings yet to be equipped, however, room is provided for an additional track running in front of the furnaces, so that the ladles can be filled without removing them from their cars. The ferro-manganese is added to the metal in these ladles by means of a steel chute, fitted with a gate which is operated from the tapping platform by means of a lever. The filled ladles are carried by the 125-ton cranes to the platforms for pouring the ingots. These ingots are 65½ ins. high, 18¾ × 22¾ ins. at the top and 20 × 24 ins. at the bottom, weighing about 8,250 lbs. each. There are two stripper houses (one at the rail mill and the other at the billet mill), with 200-ton electric cranes for stripping the ingots.

Rail Mill.

The rail mill is the largest in the world, and has a capacity of 4,000 tons of 80-lb. rails in 24 hours. Features of much more importance than its size are (1) its machinery is operated entirely by electric motors, and (2) it is the only motor-driven mill in the world which rolls rails direct from the ingot without reheating. The main building is 990 × 76 ft., and at right angles to it is a building 1,350 × 84 ft. for the soaking pits which serve both the rail and billet mills. Each of the 12 soaking pits for the rail mill has four chambers 6 ft. square, each accommodating four 4-ton ingots, 20 × 24 ins. The doors are operated by hydraulic power, and the ingots are handled by 7½-ton electric traveling cranes. Each pit is served by a Hughes gas producer. The rolling mill machinery was described in some detail in our issue of March 4, 1909.

The electric operation of the roll trains by electricity has been mentioned as one of the striking features of the mill equipment. These roll trains are driven by six 6,600-volt induction motors: three of these are of 6,000 HP., with speeds of 75, 83⅓ and 88 r. p m.; one is of 2,000 HP. at 68 r. p. m., and two are of 2,000 HP. with a speed of 214 r. p. m. The two high-speed motors have 50-ton flywheels built up of steel plates riveted together. In the others, the flywheel effect is provided by cast-steel rims bolted to the spiders of the motors. These rims can be replaced with others of different weight, if necessary, as the actual flywheel capacity necessary to overcome the extreme load due to rolling can be determined definitely only by actual test. One of the 6,000-HP. induction motors of the rail mill is shown in Fig. 9.

The stopping of these immense motors in case of emergency is an important matter, and formed a difficult problem, as it was found that when disconnected from the rolls it took two hours for the 200-HP. motors (214 r. p. m.) and 1½ hours for the 6,000-HP. motors (83⅓ r. p. m.) to come to rest. These periods have been reduced to 2 min. 55 secs. and 1 min. 42 secs., respectively, by introducing direct-current at 250 volts into one phase of the winding, through an external resistance after the motor has been disconnected from the 6,600-volt line.

The finished rails go to the inspection beds in the finishing department, and are then loaded for shipment. The empty cars stand on tracks having a slight grade, so that when loaded they can be run by gravity to the end of the yard, ready for distribution by the switching locomotives.

Two views in the rail mill are shown in Figs. 10 and 11, and these give some idea of the massive and ponderous character of the electrically-driven machinery. Fig. 10 shows the 40-in. blooming mill, which is directly connected to the 6,000-HP. electric motor shown in Fig. 9. Fig. 11 shows the transfer to the first 28-in. rolls of the finishing mill.

Billet Mill.

This mill is parallel with the rail mill, and is electrically operated. It has four 40-in. blooming mill stands, each pair driven by an electric motor of 2,000 HP., and a five-stand continuous 32-in. mill driven by a motor of 6,000 HP. Beyond this are two blooming shears for blooms 12 ins. and 10 ins. square. The blooms go then to a 24-in. six-stand mill (6,000-HP. motor) or to a cooling bed for shipment. The billets from this mill may pass on to one 18-in. six-stand mill (6,000-HP. motor), or they may be sheared and delivered to a conveyor for loading into cars.

Electric Power Plant.

The power-house for generating the electric current is a building 966 × 105 ft., and is designed to serve half of the complete plant. It has 17 horizontal twin-tandem double-acting Allis-Chalmers gas engines of 4,000 HP., running at 83⅓ r. p. m., and directly connected to generators of 2,500 KW. Of these generators, 15 are 25-cycle three-phase 6,600-volt alternating-current machines, the others being 250-volt direct-current machines. The engines are said to be the largest ever built to use blast furnace gas; they have cylinders 44 × 54 ins., while those at the South Works of the Illinois Steel

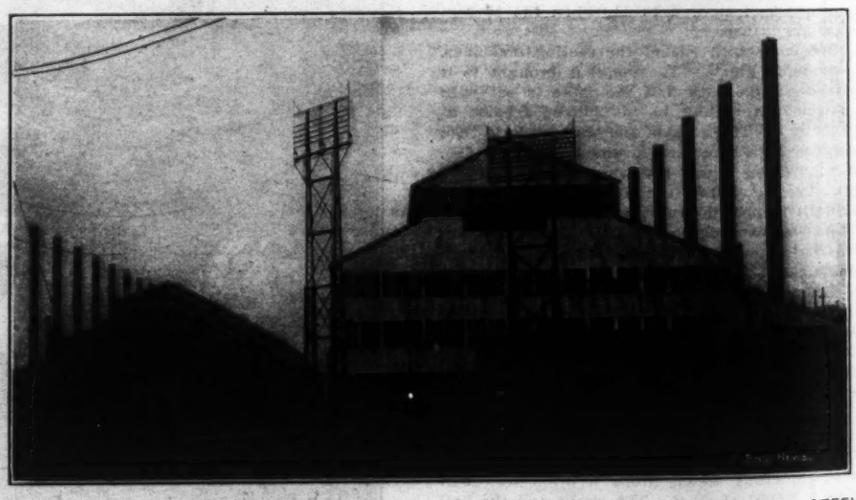


FIG. 7. BUILDINGS OF TWO OF THE OPEN-HEARTH FURNACE PLANTS, AND STEEL TOWERS FOR ELECTRIC CABLES; INDIANA STEEL CO., GARY, IND.

Co. have cylinders 42 × 54 ins. Each twin-unit has a 23-ft. 100-ton flywheel on a 30-in. shaft. A Western Electric control system provides for the control of the electrical apparatus from remote points in the plant. There are two Curtis steam turbine generator units of 2,000 KW. for starting, and for auxiliary service in case of emergency.

The distributing cables are carried by steel towers at the power station, and then to the several points of supply on steel poles set in concrete foundations. Each pole can carry 95 cables, and the height from the ground to the lowest cross arm is from 50 to 75 ft. Some of these poles are shown in Fig. 7. The insulators are 18 to 20 ins. apart; they are colored white, blue and green for the three phases, to facilitate the tracing of any trouble that may occur. Current at 6,600 volts is carried. There are three substations, and also nine transformer stations for supplying 440-volt three-phase current. A high-tension transmission line carrying 22,000 volts connects this plant with the electric power plant of the Illinois Steel Co. at South Chicago.

A storage battery plant with two batteries of 125 chloride accumulator cells is provided to regulate the load on the alternating current and direct-current lines, being charged during periods of light load. Each battery is rated at 4,320 amperes, with a capacity of two or three times that amount for a period of a few seconds.

Hydraulic Power Plant.

Water at 500 lbs. pressure is furnished for tilting the open-hearth furnaces, operating the doors of some of these furnaces, shifting the billets at the roll tables, and performing other special work. For this purpose there is a high-pressure pumping plant consisting of three Snow horizontal cross-compound condensing high-duty engines of the crank-and-flywheel type. Each engine has the steam cylinders (22 ins. and 54 ins. diameter) at one end of the frames, and the 9-in. water cylinders at the opposite end, the stroke being 36 ins. The engine and pump crossheads are connected by two large rods, and the flywheel is between the steam and hydraulic cylinders. The normal speed is 33 r. p. m., giving a capacity of 1,250 gals. per min. The maximum speed is 50 r. p. m., giving a capacity of 1,900 gals. per min. against a water pressure of 500 lbs., steam being supplied at 150 lbs. pressure. The valve gear is of the wide range Corliss type permitting cut-off up to full stroke. The steam cylinders and their heads are jacketed, and a reheating receiver is placed between the high-pressure and low-pressure cylinders.

The pump cylinders are of the outside end-packed valve pot type, with eight valves to each cylinder. The valves are of the wing type, of small diameter, but of number sufficient to give at each end an open area throught the seats equal to about twice the plunger area. The engines are governed from an accumulator, the speed increasing or decreasing as the accumulator falls or rises. The barometric condenser has a normal capacity of 20,000 lbs. of exhaust steam per hour, and a maximum of 25,000 lbs., with injection water at 70° F. and a vacuum of 26½ ins. in the condenser.

Miscellaneous Features.

BOILER PLANT.—Steam is provided for various auxiliary purposes, and also for emergency work. There are two groups of water-tube boilers (16 Stirling and 16 Rust boilers) of 400 HP. each, using blast furnace gas. These supply steam for the steam turbines in the electric power-house and the blowing engine house, the pumping engines of the hydraulic plant, and a steam turbine pump; also for such general purposes as warming the coils in the oil settling tanks and coke bins, and keeping the gas washers and valves from freezing in cold weather.

FIG. 8. INTERIOR OF POURING SIDE OF NO. 4 OPEN-HEARTH PLANT (14 FURNACES OF 60 TONS CAPACITY), WITH 80-TON LADLES; INDIANA STEEL CO., GARY, IND.

WATER SUPPLY.—The water supply is taken from Lake Michigan, and two 10-ft. conduits extend from the intake to a pump pit served by four centrifugal pumps. Each pump is driven by a three-phase 440-volt induction motor running at 500 r. p. m. Each pump has a capacity of 25,000,000 gals. per 24 hours, pumping against a head of 120 ft.

REPAIR SHOPS.—For the varied character of light and heavy repair work in a plant of this size extensive and well-equipped repair shops have been provided. These include a machine shop, blacksmith shop, boiler shop, foundry, pattern shop, etc.

TRACK SYSTEM.—An extensive system of nearly 100 miles of railway track is laid throughout the plant, all tracks being built by the Chicago, Lake Shore & Eastern Ry. The lines converge to six tracks leading to the Kirk classification yard recently built near the works by the railway company. Here the inbound cars will be sorted and sent to the proper part of the plant, while outbound cars will be delivered to the several connecting main lines.

FIG. 9. 6,000-HP., 6,600-VOLT INDUCTION MOTOR FOR DRIVING ROLL TRAINS IN THE RAIL MILL; INDIANA STEEL CO., GARY, IND.

Auxiliary Enterprises.

To provide living accommodation for the thousands of employees it was necessary to establish a new town adjacent to the works. This industrial town of Gary, Ind., has been planned on modern ideas, with regard to comfort, convenience and sanitation. Particulars of its streets, sewerage and water supply have been given in Engineering News, Nov. 7, 1907. Its present population is about 15,000.

The site of the steel works was crossed by the Baltimore & Ohio Ry. and the Chicago, Indiana & Southern Ry. By agreement with these railways, new lines were built beyond the limits of the site, involving about 10½ miles of double-track construction for the former and 8½ miles of single track for the latter. The relocation of the Lake Shore & Michigan Southern Ry. involved 11½ miles of double track. These new lines pass through the town of Gary, Ind., and are built at such an elevation as to avoid grade crossings, thus increasing the cost of construction very considerably. This work was done by the Chicago, Lake Shore & Eastern Ry., but was paid for by the steel company.

A Comparison of Steam-Driven and Electric Rolling Mills.*

By E. FRIEDLANDER,† Assoc. Am. Inst. E. E.

The first electric-driven steel rolling mill in the United States was installed about four years ago by the Carnegie Steel Co. at the Edgar Thomson Works. Since then, a number of other electric-mill drives have been installed and run with entire success, a noteworthy example being found in the steel plant at Gary, Ind.

The introduction of the electric drive has made it possible to clear up many points in regard to the power required for rolling different shapes of steel, and moreover, the operator is able to see at a glance the work done by each pass. The electric-roll drive also has shown how to get the best relations among rotating masses, speed, time and power. It has helped the roll designer to calibrate rolls in such a manner that the power characteristic for all the passes is uniform, thereby avoiding high power peaks, decreasing the size of the prime-mover, and reducing first cost and fuel consumption.

The watt-hour meter warns the operator of bearings or rolls becoming tight and hot, or of steel that is causing excessive friction in the passes, often due to overfilling, cooling or faulty calibration. This guards against damage to the rolls and bearings. The meter indicates that lower heat, greater elongation and especially change of profile in different directions, increase the power required at the rolls much more rapidly than do chemical hardness, high tensile strength, or larger drafts. The meter also shows that it is not the higher percentage of carbon in steel which requires more power in rolling but the lower temperatures at which this steel has to be rolled, and also that an increase in width of the steel shape requires more power than a decrease in height. By means of the meter, too, it can readily be seen that rolling "squares" and "rounds" takes much less power per square inch of displacement than shapes with large peripheries and many flanges, as the latter cool off quickly and cause much friction in the rolls.

Tests on rail-mills have shown that the foot-pounds per square inch of displacement gradually increase the nearer the rail is to the finishing pass. A 75-lb. rail required 1,100 ft.-lbs. at the first pass on the first "rougher." On the same stand in the seventh pass it required 3,000 ft.-lbs.; in the first pass on the second roughing rolls 4,800 ft.-lbs., in the fifth pass 8,150 ft.-lbs.; 9,500 ft.-lbs. were required for the last or finishing pass. The large increase in foot-pounds is partly due to the greater density and the rapid cooling of the steel, especially near the thinner flanges at the finishing pass. For this reason, the flanges are rolled out as late as possible. Whenever required, exact power consumption can be found for each phase of rolling.

FIG. 10. 40-IN. BLOOMING MILL DIRECTLY CONNECTED TO 6,000-HP. ELECTRIC MOTOR. United Engineering & Foundry Co., Pittsburg, Builders.

FIG. 11. TRANSFER TO 28-IN. ROLLS OF FINISHING MILL IN THE RAIL MILL OF THE INDIANA STEEL CO., AT GARY, IND.

The ideal motive power for rolls should drive them slowly when the steel enters and faster as the piece lengthens. The reciprocating engine will do just the reverse. It will run very fast without load and slow down as the load increases, finally stopping if the load becomes too great. The maximum torque of reciprocating engines is fixed by the size of the cylinders and the pressure; it cannot be increased no matter how much steam or gas is available. For this reason most mill engines are made very large and often run on only half load, with abnormal steam consumption, the most economical cut-off being at full load.

For this work the characteristics of the electric motor are much better. Even at double the full torque, the efficiency is good and the motor will not stop. But it will take more and more current, finally burning unless protected. If desirable, speed changes from no load to full load can be made small. The current can also be limited to a certain maximum, without stopping the motor. In this manner excessive strains and serious breakdowns are prevented. Where high speeds are necessary, motors can be direct connected to rolls, increasing the energy of the rotating parts and at the same time decreasing the size of motor, the power required and the fuel consumption. Heavy reciprocating engines cannot run at such high speeds, and must be connected to the rolls by means of gears, ropes or belts.

To obtain accurate information as to the exact power requirements for rolling steel, preliminary to the use of electric motors, indicator diagrams have been taken on reciprocating engines doing similar work, but these in many instances have been misleading. The work of rolling steel is very changeable and engines often run with light loads but at short intervals have the valves wide open. This, together with the work done due to the energy of the rotating parts, should be carefully observed. Although probably it is not difficult to find the maximum torque required to determine the normal capacity of the motor, the above-mentioned points must be considered, together with the length and number of pieces in the rolls, and the time-intervals between passes. To be on the safe side it is advisable to follow standard mill practice yet and to make motors of ample size and strength, in order to stand the severe service and overloads without injury.

In mentioning fly-wheels, the writer had only three-high non-reversible mills in mind. As the weight of rotating parts is much greater in large motors than in reciprocating engines, and the energy of the rotating parts increases as the square of the speed, it is obvious that even a small change in speed is of great importance. As tests have shown that rotating masses are sometimes worse than useless, careful study of this feature has to be made in each case. While the steel is being rolled, both the motor and the fly-wheel should furnish the power, but as soon as the steel leaves the rolls the motor should accelerate the rotating masses to the same speed before rolling. The time available and the number of revolutions to be made will determine the size of the motor more than anything else.

It has been observed, on blooming and roughing mills where the pieces are very short and the intervals are long, that the rotating masses supply the most energy during the rolling period and should therefore be large. The reverse takes place at the finishing passes, where pieces are long and follow each other rapidly. Heavy rotating masses would in this case be useless, and would even require larger motors for their quick acceleration. Where one motor drives both roughing and finishing rolls, curves should be plotted showing the number of pieces in the rolls at the same time, the length of passes and intervals, the power required for each pass, etc. With the help of such curves, the best relation between the size and speed of the motor and the fly-wheel, radius of gyration, etc., can be easily determined.

The total power required in a steel plant fluctuates continuously, the average in many plants being often below one-fourth of the total capacity of motors installed. The electric-driven rolling mills will, however, demand a considerably larger power-station to take care of the large currents, especially when all the motors happen to be overloaded at one time, as for instance when rolling cold steel. It is very important to find out beforehand how much of this fluctuating load the power-house may have to supply, assuming the worst conditions, as the shut-down of the electric power station for even a very short time, will stop the operation of a large number of machines and cause enormous losses. This is the one very objectionable feature of making such a great number of prime movers entirely dependent on one power

*From a paper presented at the annual convention of the American Institute of Electrical Engineers, Frontenac, N. Y., June 28, 1909.

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station. Therefore some means should be taken to prevent this disturbance.

With steam engines and boilers the liability of a complete shutdown is not so great but the delays and annoyances caused by low steam-pressure are of daily occurrence in many plants. In such cases not only are all the steam-driven prime movers unable to develop the required power, but also in trying to develop this power, they use more and more steam, thus making it difficult to raise the steam pressure without increasing the number of boilers, or decreasing for a while the load and consequently the production.

The short, high-peaked current demands should be kept off the power station as much as possible and only the average current should be supplied. A minimum number of generating units can then be kept running under nearly maximum load with the most economical fuel consumption and with the least wear and tear of moving parts. As before mentioned, the average current consumption in a steel plant is always small in comparison with motor capacity, on account of the intermittent work and large amount of inertia of the rotating parts. By means of storage-batteries or fly-wheel substations the occasional large demands for current can be taken off the station and supplied from these two sources, where it is stored up when the current demand is below the average. The exchange of current from one motor to another, in connection with electric roll-drives, is often considerable and should not be overlooked.

With regard to the electric reversing mill, it is a fact that soon after its first appearance the use of reversing rolls became more general, especially in England and Germany. In those countries, small quantities of one kind and shape are rolled and the cost of the large number of rolls required and the time in changing rolls are probably the chief reasons for using the reversing mill, where many different sections can be worked with the same rolls. The absence of the heavy and troublesome lifting tables is also a welcome feature, especially when pieces rolled are very long.

The first installation in this country of an electric reversing mill, at the Illinois Steel Co. works at South Chicago, has given entire satisfaction from the start, and has demonstrated that the electric motor is much better adapted for this kind of work than the reciprocating engine. Although the first cost was high, its lower depreciation, better operation and lower cost of maintenance should justify its installation.

In a reversing mill the operator is able to draw steel slowly into the rolls and "speed up" while the piece lengthens, a great advantage. In order to obtain perfect speed regulation with steam engines, no use can be made of steam expansion, but admission continues during nearly full stroke. Even then much depends on the skill of the operator, who can subject the engine and the mill to very severe shocks and can cause serious breakdowns if he is not careful. Reversing mill engines are therefore made heavy and strong. If too much steam is admitted, it is difficult to prevent such large engines from racing when without load. As both the time of actual rolling and the speed of the rolls are limited, most of the power is consumed in the rapid starting and stopping of the heavy rotating parts, without making any use of their fly-wheel energy. This gives an added waste.

With the use of electric motors in place of reciprocating engines, the problem of reversing the rolls becomes much simpler and better, in regard to manipulation, fuel consumption, and cost of maintenance. The operation of electric-driven reversing mills is nearly automatic; no skilled operator is required and all danger to the motor and the mill is eliminated. The speed of acceleration is prearranged, and no matter how fast the operator moves his levers, the maximum current and the speed are limited. Reversing is then done with the least shock to the rolls and couplings and the danger of overstraining the machinery is done away with.

Where power and speed variation are considerable, the direct-current motor, on account of its load and speed characteristics, is better adapted for driving rolls than the alternating-current motor. For reversible-roll drives it is used exclusively. There is no reason why the direct-current motor should give any more trouble than the direct-current generator at the power station. Four years' experience has shown that the wear of the commutator and the cost of maintenance amount to practically nothing. The transmission of large low-tension currents is much more serious, especially when tens of thousands of horse-power have to be supplied and the distance of the motors from the station is considerable. The use of higher direct-current voltages in connection with large rolling mill motors should be satisfactory, but no doubt high-tension alternating-current transmission and induction motors direct on the line will be generally employed, especially in new installations. Where conditions demand it, the induction-motor characteristics can now be made nearly similar to the compound-wound, direct-current motor. However, much of its simplicity and efficiency will be sacrificed in doing this.

Among some of the earlier disadvantages of the induction motor were the very large current required for starting under heavy load; one single speed fixed by the number of poles with the tendency always to run at synchronous speed, a low power-factor with light loads, the small air gaps; the impracticability of reversing large units, and the inability to change speed to fly-wheel requirements. In the design of the modern rolling-mill motor, most of these objectionable points have been remedied by different means such as wound rotors, the introduction of variable resistance, changing the number of poles, shifting the phases, slip-rings, etc.

Whether direct-current power stations with direct-current motors are used, or alternating-current stations are installed for high-tension transmission with alternating-current motors either directly on the line or fed through transformers, or whether direct-current motors are supplied from an alternating-current station through converters, motor-generators, batteries or fly-wheel substations, is a matter of detail. No doubt any one of these systems will give satisfaction if properly designed and installed.

Raising "Cricket Bat Willows," Peppermint and Other Crops on the Sewage Disposal Area of Sutton, Surrey, England.

Some brief notes relating to the historic sewage disposal works at Sutton were given in our issue of March 18, 1909. The following interesting information regarding the application of storm-water sewage to land at Sutton is extracted from a paper by Mr. C. Chambers-Smith, Engineer and Surveyor to the Urban District Council, read before the Association of Managers of Sewage Disposal Works in June, 1909. We are indebted to the London "Surveyor" for the following extract:

Clay Land and Underdrains.

The land, of which there is about 11 acres available for irrigation, is only used for sewage disposal during heavy storms or when the crops will be benefited by its application. The surface, as previously pointed out, is of London clay, which was originally underdrained when the farm was laid out in 1893. Owing to the escape of unpurified sewage into these drains during dry weather, when the clay shrinks, producing fissures, they have all been cut off with satisfactory results. Great benefit has also accrued, both as regards increasing the yield of crops and purification purposes, from the lightening of the clay soil by the addition to the surface of some thousands of loads of house refuse.

Crops.

The crops which are being cultivated during the present season are potatoes, 2 acres; mangolds, 3 acres; swedes, 3 acres, peppermint, 1 acre. One acre of land is covered with osiers which have been growing several years and are being dispensed with. This crop cannot be grown at a profit. Rye grass which has been grown in some years has never found a ready sale. About one acre of land is utilized as a nursery for the rearing of shrubs and trees, which are planted in most of the streets in the town with such good effect.

A commencement has been made with the growing of what are commercially known as "Cricket Bat Willows." This tree arrives at maturity in 12 to 15 years, when the average price obtained for it is £3 [$15] per tree, the timber being used for the manufacture of cricket bats—the demand for which greatly exceeds the supply. From 250 to 350 trees are grown to the acre. It is considered to be a fair estimate that an acre of such willows should produce £750, thus giving a gross yield per acre per annum of £50. The cost of young willow sets is 30s. [$7.30] per 100, and 600 sets costing £7 10s. are required to the acre. Special care requires to be taken in the selection of the true plant as there are several varieties, some of which are valueless. Botanically it is described as the Salix Alba var. coerulea, the stem having a perfectly smooth bark with long leaves which show a silvery white on the underside, the ordinary willow on the other hand having a long uniformly green leaf.

The young sets are from 1¼ to 3 ins. in diameter and are planted between November and March, usually with the stem to a depth of 18 ins. and 21 ft. apart. Heavy damp soils are most favorable to their growth, which is from 1 to 1¼ ins. in diameter per annum, and at the end of 15 years when ready for cutting down their diameter should be 15 ins.

It is indispensable that the timber be free from knots. Consequently, all young shoots should be stripped from the stem at least twice yearly. Cricket bat manufacturers state that the best willow is grown in Essex and Middlesex and the southeastern counties, and that the English variety excels all others.

Another crop which has been found highly profitable in cultivation is that of peppermint. Inasmuch as this was probably the first sewage works where it was grown, and the success attending it has led the management of other farms to follow the example thus set, some particulars may not be out of place:

The peppermint plant (Mentha Piperita) is cultivated for the production of oil of peppermint, known commercially as Menth. Pip. Ang. Mitcham. Its cultivation on a farm is commenced from the young plants or sets and not from seed. The usual time for planting is in the month of May. The price of the sets is 7 to 9s. per bu. [or an average of $3.90], and 8 bu. are usually sufficient for covering 1 acre, when planted 15 ins. apart. The crop, which grows freely in certain districts, appears to be successful chiefly in the south of England, and does not appear to have been successfully grown further north than Lincolnshire. It is usually ready for cutting about Aug. 1, when the plant is just breaking into flower. The crop is partially sun-dried, placed in mats, and despatched to a mint distillery, a number of which exist in the neighboring district of Mitcham. Frequently, however, the crop can be sold as growing. The yield of oil is from 18 to 35 lbs. per acre, the yield per pound ranging from 20 to 31s. [$4.86 to $8.26], so that the yield per acre ranges from £25 to £45. The cost of distillation is about £5 per acre. The roots left in the ground are covered with soil before winter sets in, thus protecting them from frost, and through this the young shoots grow in the succeeding season. It is important to notice that the plant generally exhausts its food constituents from the soil in about six years, when a complete change of crops, such as mangolds, should be made for a number of years.

Sludge Disposal.

The sludge which is produced at the sedimentation tanks at the high-level works is discharged from the tanks three times yearly by gravitation into sludge lagoons, which are at present in course of reconstruction. The sludge from the low-level tanks is pumped to the high level. The lagoons, of which there are two in number, are constructed as follows:

The sides and floor of the lagoons are formed of clay. Along the lowest part of each lagoon is constructed a 6-in. pipe drain, with branch drains 6 ft. apart laid along the floor, all of which drains are laid with open joints. Over the top of these drains and covering the whole surface to a depth of 6 ins. is laid coarse clinker, and a further layer 3 ins. in depth of ashes from house refuse is laid on the top of this, thus facilitating the rapid drainage of the liquid portion of the sludge. The effluent from the lagoon is discharged into the low-level sedimentation tanks. By this method the sludge is dried in a comparatively short space of time, while the odor therefrom quickly disappears.

A 3,265-FT. DRILL-HOLE has recently been completed on the property of the American mine on the Marquette range, near Champion, Mich., by the firm of Cole & McDonald. As reported in "The Mining Journal," of Marquette, Mich., the work was started Nov. 1, 1908, and was finished June 1, 1909, with full day's work for all that period except the loss of about one week during the holidays and ten days spent in preliminary experimenting. The drilling was started in slate about 60 ft. from the surface and passed from that into quartzite at a depth of about 1,600 ft. A core 1¼-in. in diameter was removed. It is claimed that this is the deepest drill-hole ever made in North America, though in South Africa the depths have gone above 6,000 ft. In our issue of April 15, 1909, p. 408, we noted a 3,200-ft. hole in Bisbee, Ariz., then claimed to be the deepest on this continent.

THE COMPARATIVE VALUE OF VARIOUS DUST preventives now on the market is to be studied by the State Highway Department of Ohio, according to a statement issued on Aug. 4, 1909, by Mr. James C. Wonders, State Highway Commissioner. Nelson Ave., near the city of Columbus, Ohio, has been chosen for experimental purposes. The roadway here is 16 ft. wide, and sections of it 400 ft. in length have been chosen for treatment, thus giving a continuous road, all parts of which, Mr. Wonders states, will receive the same amount of travel. Dust preventives have already been applied on a number of sections. As to the kinds of dust preventives to be tested, we quote the following from Mr. Wonders' statement:

We expect to have a section treated by Carbo-Via; Standard Oil asphaltic treatment; Kentucky Rock Asphalt; Asphaltollene; the Indian Refining Co.'s product; the Impervious Product Co., of Baltimore; the American Asphaltum & Rubber Co., of Chicago; the Barrett Mfg. Co., Tarvia and Tarvia X; the Robeson Process Co., of New York; Taroid; United Gas & Improvement Co., of Philadelphia; and the Petrolithic Pavement Co., of Los Angeles, Cal. We also expect to construct two sections, using Portland cement for binder.

Mr. Wonders informs us that Mr. Selts, Assistant State Highway Commissioner, has personal charge of the work, and will be pleased to extend information and courtesies to those who are interested in it. He also says that the experimental sections of road can be reached from the city of Columbus in 20 minutes on the Columbus, New Albany & Johnstown interurban cars.

Tests of Standard and Wide-Flange I-Beams.*

By EDGAR MARBURG.†

The new Bethlehem Special I-beams and Girder beams, rolled on the Grey universal beam mill, at the works of the Bethlehem Steel Co., South Bethlehem, Pa., differ in certain important particulars from the so-called "standard" beams. In the Grey mill the flanges and web of the beam are formed by the simultaneous operation of independent horizontal and vertical rolls, thus admitting of the effective rolling of the metal in the flanges as well as the web. This renders it possible to produce wider flanges than by beam mills of the ordinary type in which the linear speed of rolling at different points of the beam varies inversely with the distance from the center of the roll, resulting in a dragging action upon the flange metal, which becomes emphasized with increasing flange width.

It is claimed that sections produced by the Grey process are subjected to uniform reduction in rolling at all parts of the shape, resulting in greater uniformity in the physical properties of the material throughout the section, and in the avoidance of internal stresses, and that, in consequence, under nominally the same working stresses, they possess a larger safety margin than beams made by the usual method. It is further claimed that the webs of the standard beams are unnecessarily thick for economy, but that it is not practicable to reduce their thickness in the ordinary mill. Compared with the lightest standard beams of like depth, the lightest Bethlehem Special I-beams are designed so as to possess the same section moduli at weights uniformly 10% less. This is effected by a material decrease of web section and a slight increase of flange section, the comparison for the lightest 24-in. and 15-in. beams being approximately as follows:

WEB AND FLANGE SECTIONS IN SQUARE INCHES.

	Min. 24-in. Beams.		Min. 15-in. Beams.	
	Std. 80-lb.	Bethl. 72-lb.	Std. 42-lb.	Bethl. 38-lb.
Web section.....	10.9	8.1	5.5	3.8
Flange section....	12.4	13.1	7.0	7.4
Total	23.3	21.2	12.5	11.2

The slope of the flanges of the Bethlehem beams is one-fourth less than that of the standard beams, or 1 on 8 instead of 1 on 6.

The Girder beams are so designed that the lightest section of a given depth up to 20 ins. possesses just twice the section modulus of the lightest standard beam of corresponding depth, whereas their weight averages about 12.5% less than the double weight of the latter. The web thicknesses are practically identical, the difference lying chiefly in the greatly increased width and slightly increased thickness of the flanges. For the greatest depth of standard beams, 24 ins., the section modulus of the lightest girder beam is somewhat less than twice that of the lightest standard beam.

The lightest section of each of the three types, for depths of 15, 24 and 30 ins., is shown in Fig. 1. The largest girder beam is 30 ins. deep and weighs 200 lbs. per ft.; the largest standard beam is 24 ins. deep and weighs 100 lbs. per ft. The section moduli are 610 and 198 respectively, the former being more than three times as great as the latter, although the weight is only twice as great, this advantage being, of course, due partly to the difference in depth, and partly to the more favorable distribution of the material between the web and flanges.

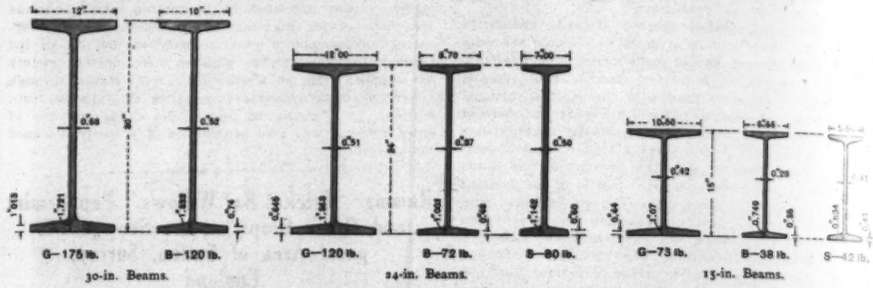


FIG. 1. DIMENSIONS OF I-SECTIONS TESTED.

The claims advanced in favor of the Bethlehem as compared with the standard beams, briefly summarized, are:

1. That the material in the flanges receives more work in rolling and is, therefore, of better quality.
2. That the material throughout the section is more nearly uniform in quality.
3. That the beams are comparatively free from internal stresses.

If these claims are valid, it obviously follows that the Bethlehem beams are stronger for like section moduli, provided the relatively thin webs do not induce premature failure by buckling.

Tensile Tests.

Three tensile tests were made on specimens cut from the beams from each heat of steel, one specimen to be taken from the web, another from the flange, and a third from the root. The finished specimens were all 1.5 ins. wide, with planed edges, and occupied approximately the positions in the sections indicated in Fig. 2. The elongations were measured on an 8-in. gage-length with a Ewing [microscope] extensometer.

The results of these tests, reduced to unit elongations, are typically illustrated by Fig. 3, and are summarized in Table I herewith.

The most notable feature is the remarkably low values of the elastic limit in five of the seven specimens from the root, particularly in the case of the Bethlehem 15-in. girder beams, for which the elastic limit at the root was only 11,000 lbs. In six of the seven sets of specimens the elastic limit was highest in the web, as was to be anticipated, and in the seventh set the flange specimen gave a slightly higher value.

The abnormal character of the material in the specimens which displayed such low elastic limits is further apparent from the fact that the ratio of the yieldpoint to the elastic limit is, in these cases, much higher than in properly finished structural steel. This is clearly apparent in the stress-deformation curves, Fig. 3, in which the highest point on each curve usually represents the yield-point, and from Table I. It is obvious, therefore, that the determination of the yield-point by the drop of the scalebeam, gives, under such circumstances, not even approximate information as to the value of the true elastic limit.

It is noteworthy that certain specimens which exhibit decidedly low elastic limits run particularly high in ultimate strength.

Unfortunately, the inferior material exists at the root or the thickest part of the flange, where its effect on the strength of the beam is greatest. For fuller information as to the variability of the metal, it would be desirable to cut the entire section longitudinally into a series of thin strips of suitable length. By taking accurate extensometer measurements between a pair of contact points on each strip, before and after it is separated from the beam, its state of initial stress may be determined. While there seems to be some justification for the claim that Bethlehem beams possess greater freedom from initial stresses than standard beams, experimental proof is needed for its actual demonstration.

The claim of superior uniformity in the physical properties of the material throughout the section, advanced in favor of the Bethlehem beams, is not substantiated by the tests. Of the six Bethlehem beams in which the material was subjected to tensile tests, the uniformity with respect to the elastic limit was good in one case, fair in another, and bad in the remaining four. In the last four cases the elastic limit of the web exceeded that of the root by 195, 126, 99 and 74%, respectively. The writer regrets that he was not afforded the desired opportunity of making numerous additional tests of this character. In the light of these results it would seem that the material in the vicinity of the root received insufficient work, or was finished at too high a temperature, or both, in the Bethlehem as well as the standard beams.

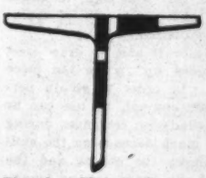


Fig. 2. Sketch Showing Location of Tension Test Specimens (Web, Flange and Root).

Bending Tests.

The first 9 beams were tested under central load, the 24 others under two equal loads concentrated at the quarter-points [giving the same shear and the same moment maxima as under uniform load, but over a larger part of the beam.]

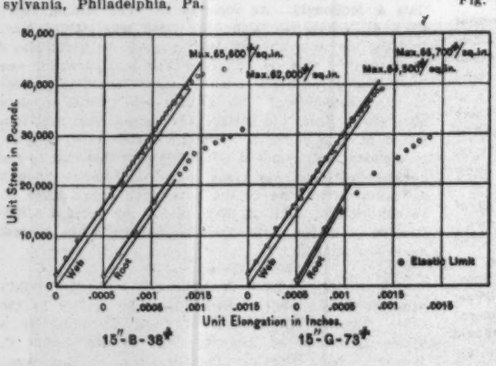
The load was applied by means of a 600,000-lb. Olsen testing-machine, through a spherical bearing block with a flat lower surface acting on the cylindrical surface of a segmental block of hardened steel. [For the quarter-point loading this set of blocks acted on a 14-in. 265-lb. H-section beam about 12 ft. long, which pressed down upon the test beam by segmental blocks or rockers resting on rollers to eliminate longitudinal strain. The end supports of the test beam in all cases were self-adjusting bearings, but no motion in these bearings was discernible after the initial loads of a few thousand pounds, except in a few cases after failure by twisting of the web, when the lateral thrust from the inclined web was sufficient to make the bearing turn. See Figs. 7, 8, and 9 for views of various parts of the mounting.—Ed.]

MEASUREMENTS.—Deflections were measured by a pointer on a wooden bar resting on supports at the ends of the neutral axis of the test-beam. A pointer on the bar played over a scale attached to the web of the beam at mid-span.

Flange stresses were measured in all the quarter-point loading tests, by four Johnson

*Abstract of a paper read before the American Society for Testing Materials, at Atlantic City, N. J., June 28-July 3, 1909.

†Professor of Civil Engineering, University of Pennsylvania, Philadelphia, Pa.



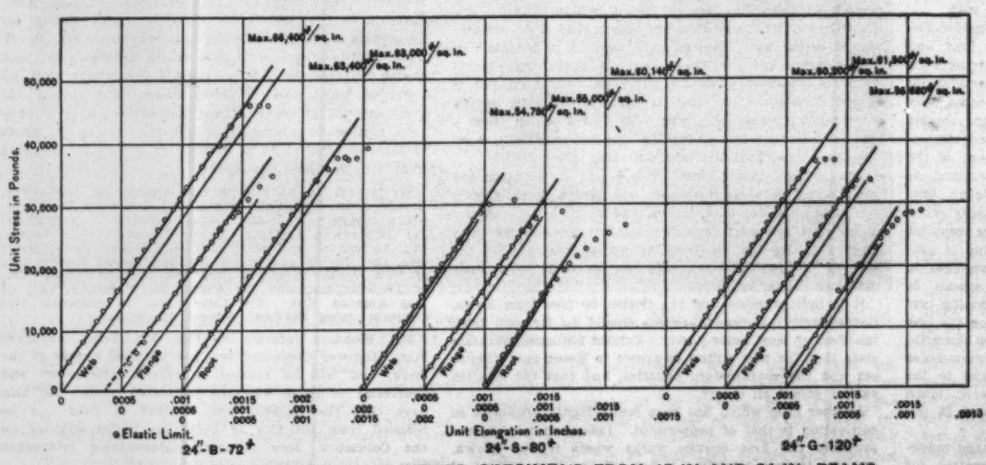


FIG. 3. TENSILE-TEST CURVES OF SPECIMENS FROM 15-IN AND 24-IN. BEAMS.

dial extensometers attached along the two edges of upper and lower flange. The gage-length was 40 ins.

In the earlier tests the attempt was made to observe the lateral deflection of the upper flange by clamping longitudinal bars—light flats or angles—along both sides of the flange, as shown in Fig. 7, and reading these deflections to the nearest 0.01 in. by means of graduated wedges inserted at any desired points between the outstanding edges of the flange and the longitudinal bars. It was found that slight, irregular movements occurred during the early stages of loading while the beam was apparently adapting itself to its bearings. No subsequent movements were then discernible until the elastic limit of the beam had been exceeded and usually not until the ultimate strength had been nearly reached. Since these measurements were very time-consuming, and appeared to furnish little or no useful information, they were omitted in the later tests. The records of these measurements in connection with the earlier tests are not regarded as of sufficient value for reproduction.

ELASTIC LIMIT.—The values of the elastic limit in bending given in the tables are the computed extreme-fiber stresses for the loads above which the load-deflection ratio ceases to remain constant. As a measure of extra precaution, after a load had been released in order to take observations for permanent set, a return was always made to that load, and the deflection re-read before applying the next load-increment. For beams B 11, B 12 and G 27, the load corresponding to the elastic limit, as above defined is slightly less than that which produced the first permanent set; for beams G 18, B 28, G 32 and G 26, these two loads are identical; for the remaining 24 beams of the 31 tested, the elastic-limit load is greater, and in some cases very much greater, than the permanent-set load.

The best survey of the entire field may be had from Fig. 6, in which the individual values for each group are plotted on a descending scale. The following are the most important deductions from this diagram:

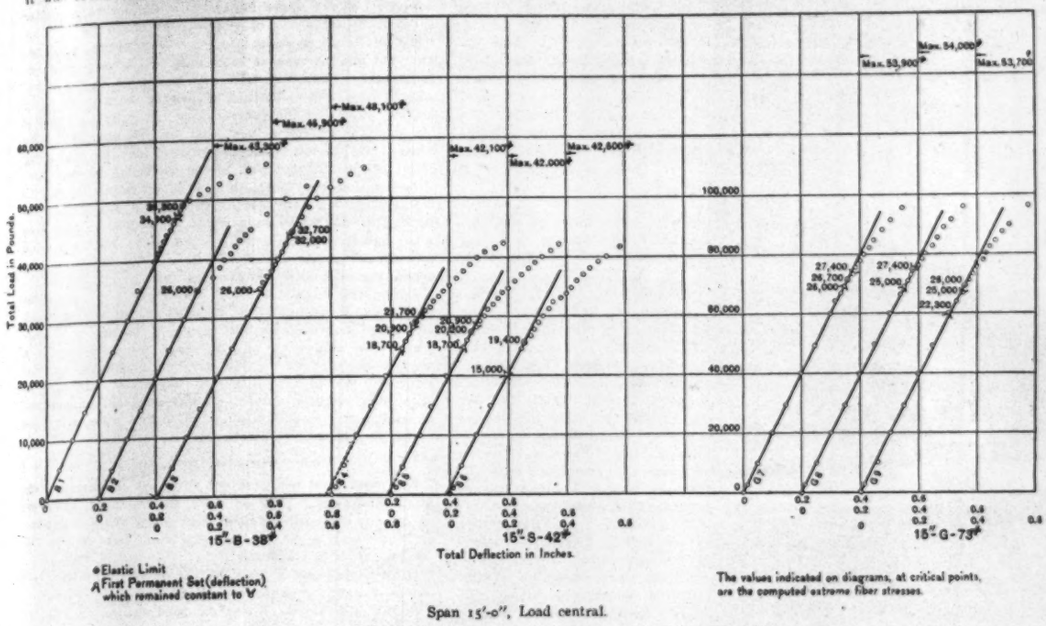
1. That the elastic limit of the standard beams is very nearly constant, the average value lying slightly above 20,000 lbs. per sq. in.

2. That the elastic limit of the Bethlehem special I-beams is much lower for quarter-point than for central loading, and that this is true also, though in a less degree, of the girder beams. A partial explanation may, perhaps, be found in the fact that with the former loading, the maximum fiber stress is developed throughout the middle half of the beam instead of at the central section only; although this applies equally to the standard beams, which exhibit no such difference in their behavior.

3. That the elastic limit of the 15-in. Bethlehem beams is much higher than that of the 15-in. standard beams, under central loading, and slightly higher under quarter-point loading.

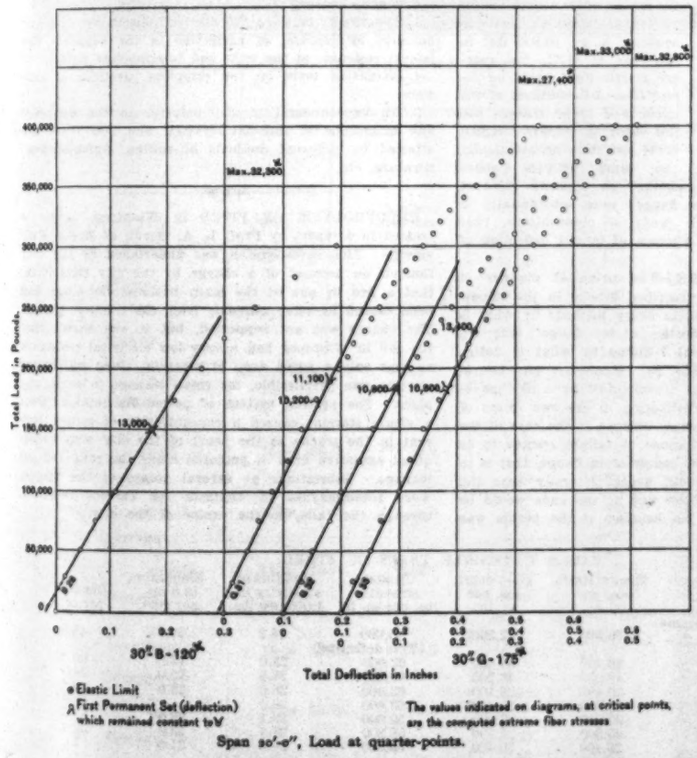
4. That the elastic limit of the Bethlehem beams declines very rapidly for the larger sections, reaching finally the remarkably low value of 10,800 lbs. for the 30-in. Girder beam G 32, the values for the other two beams of that set being only slightly higher.

These values are so surprisingly low that they merit more detailed consideration. On reference to the load-deflection diagrams of these three beams, Fig. 5, it is seen that for G 31, and G 33, they show a slight curvature, even below the elastic limit, and that by the most liberal interpretation no higher values than those designated can be assigned to the elastic limit. It is also seen that permanent set was observed in each case at or below the load corresponding to the elastic limit. As previously stated, these beams were mounted on cylindrical bearings resting on flat plates, to admit of their better adjustment to any irregularities in the beam. This circumstance cannot account, however, for the low values of the elastic limit. First, because the flanges remained in perfect alinement till shortly before failure, and second, because in the test of the single Bethlehem 30-in. special I-beam, B 28, a curved lower bearing block was used, instead of a flat plate, and yet the elastic limit in this instance, 13,000 lbs., is 400 lbs. lower than that of the 30-in. Girder beam, G 33. Further corroborative evidence as to the remarkably low value of the elastic limit of these 30-in. girder beams is to be found in the fiber-deformation measurements performed directly on the flanges themselves, which will receive further attention below. The writer expected to have the opportunity of making additional tests on such beams, mounted on flat end-bearings resting on rollers. In his opinion, this change would, how-


Total Load in Pounds.
Total Deflection in Inches.
15" B-38#
15" S-42#
15" G-73#
Elastic Limit
First Permanent Set (deflection) which remained constant to V
The values indicated on diagrams, at critical points, are the computed extreme fiber stresses.

Span 15'-0", Load central.

FIG. 4. LOAD-DEFLECTION CURVES OF 15-IN. BEAMS.


Total Load in Pounds.
Total Deflection in Inches
30" B-120#
30" G-175#
Elastic Limit
First Permanent Set (deflection) which remained constant to V
The values indicated on diagrams, at critical points, are the computed extreme fiber stresses

Span 30'-0", Load at quarter-points.

FIG. 5. LOAD-DEFLECTION CURVES OF 30-IN. BEAMS.

FIGS. 4 AND 5. BENDING-TEST CURVES FOR 15-IN. AND 30-IN. BEAMS.

(Abscissas represent deflection at midspan; ordinates represent total load; figures marked on curves are computed extreme-fiber stresses in pounds per square inch.)

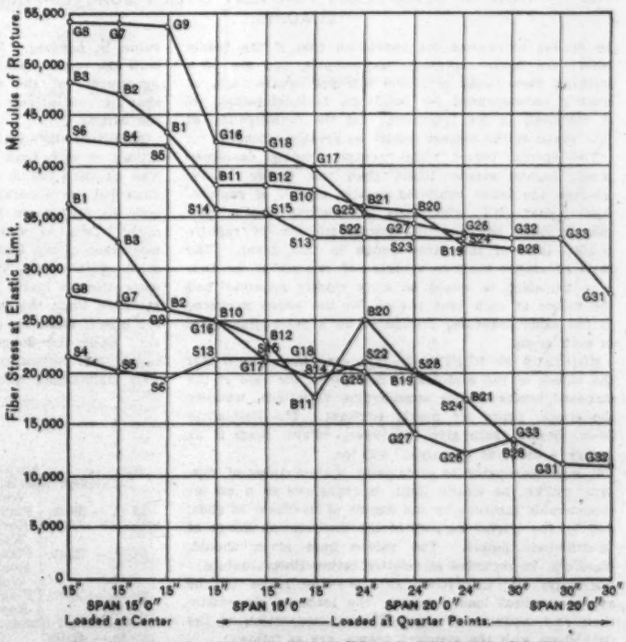


FIG. 6. SUMMARY OF RESULTS OF BENDING TESTS.

Upper Curves: Modulus of rupture plotted on descending scale.
Lower Curves: Elastic limit plotted on descending scale.

ever, have had no effect on the elastic limit, because *the alinement of the flanges in these tests was unaffected up to loads far beyond the elastic limit.* This is also clearly shown by the close agreement of the fiber-deformation readings on opposite sides of the flanges.

The writer will hazard no explanation as to the cause of these remarkably low values of the elastic limit; but he desires to express his conviction that if the beams tested are fairly representative samples, the use of a working fiber stress of 16,000 lbs. per square inch, as usually recommended for buildings, is indefensible. It is essential, in his judgment, that the investigation of this phase of the subject should be greatly extended.

FIG. 7. VIEW OF BEAM READY FOR TEST UNDER QUARTER-POINT LOADING.

The special beams under central loading developed much higher elastic limits than the Girder beams, whereas the latter exhibited greater moduli of rupture. Again, beam B 1, which has the highest elastic limit (36,300 lbs.), has also the lowest modulus of rupture (43,300 lbs.) of the three beams in that group. The ratio of elastic limit to modulus of rupture is, in fact, very variable, as would be more readily apparent had the values of each been plotted for the beams arranged in the same sequence, instead of on a descending scale in each group.

MODULUS OF RUPTURE.—It is seen from Fig. 6 that the values of the modulus of rupture in the case of the standard beams exhibit considerable variations, whereas the elastic limits are nearly constant. The Bethlehem 30-in. beams again give the lowest values, beam G 31 having a modulus of only 27,400 lbs.

It may reasonably be anticipated that modulus of rupture, unlike the elastic limit, is influenced in a no inconsiderable measure by the degree of fixedness of ends, and by the lateral support of the compression flange at intermediate points. The values here given should, therefore, be regarded as relative rather than absolute.

RATIOS OF CRITICAL LOADS.—The ratios of the average critical loads, namely, the loads at the elastic limit and modulus of rupture, in a comparison of the Bethlehem with the standard beams, are as follows:

	Average Ratios of Critical Loads.					
	Elastic limit.			Modulus of rupture.		
	15-in. beams.			15-in. beams.		
Beams compared.	Ctr. load.	¼-pt. load.	24-in. beams.	Ctr. load.	¼-pt. load.	24-in. beams.
Bethl. I. / Stand. I.	1.56	1.06	1.04	1.09	1.09	1.05
B. Girder. / Stand. I.	2.64	2.19	1.83	2.56	2.38	1.81

As previously stated, the Bethlehem special I-beams have the same section moduli as the standard I-beams, and the Bethlehem girders have, in general, twice the section moduli of the latter, comparing always the lightest beams of each type and depth. It is seen that the ratio unity is more than realized by the Special beams, and the ratio 2 is exceeded by the 15-in. Girder beams; but that the ratios for the 24-in. Girder beams are considerably below 2. It is to be observed, however, that in the case of these beams, the section modulus of the girder beam is about 11% less than twice that of the standard beam.

Comparing the average values for the three 30-in. Girder beams with those for the single 30-in. Special I-beam, the ratios of the loads at the elastic limit and modulus of rupture are found to be 1.34 and 1.43, respectively, whereas the ratio of their section moduli is 1.49.

MODULUS OF ELASTICITY.—The modulus of elasticity in bending is nearly constant, its average value for the 31 beams tested being 26,300,000. The average modulus from the tensile tests, after rejecting the value 35,000,000 for the abnormal specimen from the root of the 15-in., 73-lb. Bethlehem girder, is 28,700,000 lbs. per sq. in., or nearly 10% higher than the modulus in bending, this difference being in general agreement with observations of a similar nature by other investigators.

FIBER - DEFORMATION CURVES.—The fiber stress corresponding to the elastic limit in bending is, in the great majority of cases, lower than that based directly on the recorded fiber deformations. For the 30-in. Girder beams, which exhibited such low elastic limits in bending, e. g., 10,800 lbs. in the case of G 32, the average elastic limit based on direct fiber deformations of the upper and lower flanges has the value ½ (13,400 + 8,800) = 11,100 lbs., or practically the same as the above value in bending. The readings on opposite sides of both the upper and lower flanges were substantially in agreement for the entire range of observations, thus showing conclusively the absence of lateral deflection of the flanges.

MANNER OF FAILURE.—The principal manner of failure of each beam is described briefly in the tables. The standard beams failed in every instance by what is described as "Lateral deflection of top flange" [Fig. 8], and the Bethlehem Special I-beams by what is designated "Twist of web" [Fig. 9]. Manifestly any lateral movement of the flange is accompanied by a like movement of the web. The distinction in the two forms of designation is made, however, because in the case of the standard beam the initial cause of failure seemed to be the lateral weakness of the compression flange, that is to say, while the flange would deflect laterally near the center, the verticality of the web at the ends would be well maintained, unless the bending of the beams was continued, under rapidly decreasing loading, far beyond the point at which the load had reached its maximum value. The failure of the Special beams was, on the contrary, generally speaking, marked by a sudden and considerable twisting of the web—usually in opposite directions at opposite ends, the beam as a whole assuming the form of a very flat letter S—the flanges remaining comparatively straight.

The characteristic failure of the 15 and 24-in. Girder beams, under quarter-point loading, was by the lateral deflection of the upper flange, in a manner very similar to that of the standard beams. Owing to the greater width of flange in these beams, this deflection, once begun, did not increase as rapidly as in the case of standard beams. The 30-in. Girder beams failed by the twisting of the web. The 15-in. Girder beams, centrally loaded, failed, on the contrary, by the wavy buckling of the outstanding edges, vertically, in the vicinity of the center, the metal being apparently too thin to bring about failure through the lateral deflection of the compression flange. When this form of failure began to manifest itself, there was no evidence of any lateral deflection of the flange as a whole. The load in this case was applied through a plate 7 ins. wide, resting on the top flange. Since the flanges are 10½ ins. wide, the edges projected to a width of 1¾ ins.

In general it may be said that there was in no instance any evidence of the buckling of the web in detail vertically, not even at the points of loading and support. The web in twisting assumed the curvature of a warped surface, that is to say, its originally vertical elements became inclined, but remained straight, or grew very slightly curved, as was apparent on the application of a steel straight-edge to the webs after the beams had failed.

Conclusions.

The number of tests are not sufficient to warrant definite conclusions. They do point out the need, however, of greatly extended investigations along these and similar lines, with a view of throwing more light on the following points in particular:

1. The low elastic limit of the metal near the root of the flange: its cause and prevention.

2. The low elastic limits in bending for the deeper beams: the cause and prevention, unless it can be proven conclusively that the values obtained in the present series are abnormal.

3. The effect, both on the elastic limit in bending and modulus of rupture, of variations in the supports and lateral restraint at the ends and intermediate points.

4. Extensive tests on the crippling strength of thin webs.

5. An experimental inquiry relative to the existence and magnitude of internal stresses, and how these are affected by different methods of rolling, finishing-temperature, etc.

ELECTROLYSIS OF PIPES in Winnipeg, Man., is treated in a report by Prof. L. A. Herdt, of McGill University. This investigation was undertaken by the City Council on account of a charge by the city electrician, that a fire in one of the main business buildings had been caused by stray currents from the traction system. The charge was not supported, but it was shown that the soil in Winnipeg had a very low electrical resistance so that only a small drop of potential along rail-return circuits was permissible, for small leakage to earth and pipes. The present system of power distribution, from a single station, caused a concentration of return current in the tracks in the heart of the city with consequent excessive drop of potential along the rails and out leakage. Substations at several points of the system were recommended to diminish the current returned, through the rails, to the center of the city.

TABLE I.—TENSILE TESTS OF STEEL.

Size.	Location.	Elastic limit, lbs. per sq. in.	Yield point, lbs. per sq. in.	Ultimate strength, lbs. per sq. in.	Modulus of elasticity in 1,000,000 lbs.	Elongation in 8 ins., per cent.	Reduction per cent.
Bethlehem Special I-beams:							
15-in.— 38-lb.	Web.	36,800	42,500	65,600	28.2	27.5	48.5
	Flange.			Test defective.			
	Root.	16,300	34,400	62,000	28.0	17.5	36.6
24-in.— 72-lb.	Web.	43,000	46,200	66,400	28.5	25.0	48.0
	Flange.	26,400	36,100	63,400	28.0	29.0	57.5
	Root.	33,800	39,400	63,000	28.4	....	53.8
30-in.—120-lb.	Web.	26,700	37,000	59,600	29.1	32.0	53.5
	Flange.	25,800	31,500	58,800	28.3	33.0	59.6
	Root.	26,400	30,400	58,900	28.0	31.0	57.0
Standard I-beams:							
15-in.— 42-lb.				No test specimens furnished.			
24-in.— 80-lb.	Web.	24,500	30,500	54,800	28.9	....	30.9
	Flange.	25,400	28,400	55,000	29.2	34.6	61.2
	Root.	15,200	28,100	60,100	30.4	25.0	57.7
Bethlehem "Girder" Beams:							
15-in.— 73-lb.	Web.	32,500	41,400	64,500	29.0	27.7	46.4
	Flange.			Test defective.			
	Root.	11,000	32,500	66,700	35.0	28.6	43.7
24-in.—120-lb.	Web.	35,[illegible]0	36,400	60,200	28.4	31.0	55.3
	Flange.	31,900	33,300	61,500	28.7	34.8	65.1
	Root.	20,200	29,300	56,700	29.6	....	61.2
30-in.—175-lb.	Web.	34,000	34,900	59,500	28.7	32.0	62.5
	Flange.	25,500	32,400	61,800	29.3	34.0	63.3
	Root.	17,100	28,200	59,400	28.6	35.0	59.8

Note: Specimens approximately 1.50 ins. wide; thickness varied from 0.25-in. to 1.36 ins. All flange test-pieces were of trapezoidal section.

Fig. 8. 15-in. 42-lb. Standard Beam.

Fig. 9. 24-in. 72-lb. Bethlehem Beam.

FIGS. 8 AND 9. TWO TYPICAL BEAM FAILURES.

TABLE II.—RESULTS OF BENDING TESTS OF I-BEAMS.

Lab. No.	Type.	Size.	Section modulus.	At elastic limit.—Deflection, in ins. Δ	At elastic limit.—Fiber stress lbs. per sq. in. S	At elastic limit.—Modulus of elasticity in 1,000,000 lbs. E	Modulus of rupture, lbs. per sq. in. K*	Modulus of rupture, lbs. per sq. in. K'*	Principal Manner of Failure.
15-in. I-Beams. Center Loading. Span, 15 ft.									
B 1	Beth. I.	15-in. 38-lb.	59.0	0.50	36,300	26.9	37,800	43,300	Twist of web.
B 2				0.35	26,000	27.5	44,500	46,900	
B 3				0.46	32,700	26.3	44,300	48,100	
	Average.			0.44	31,700	26.9	42,200	46,100	
S 4	Std. I.	15-in. 42-lb.	58.9	0.28	21,700	26.1	37,200	42,100	Lateral deflection of top flange.
S 5				0.27	20,200	26.3	38,600	42,000	
S 6				0.26	19,400	26.3	39,400	42,600	
	Average.			0.27	20,400	26.2	38,400	42,200	
G 7	Girder.	15-in. 73-lb.	118.3	0.36	26,700	27.4	50,900	53,900	Wavy buckling of top flange near center.
G 8				0.38	27,400	26.7	50,300	54,000	
G 9				0.36	26,000	26.7	48,000	53,700	
	Average.			0.37	26,700	26.9	49,700	53,900	
15-in. I-Beams. Quarter-Point Loading. Span, 15 ft.									
B10	Beth. I.	15-in. 38-lb.	59.0	0.46	25,000	26.6	....	37,600	Twist of web.
B11				0.33	17,400	25.7	....	38,000	
G12				0.42	23,100	27.0	....	38,000	
	Average.			.40	21,800	26.4	....	37,900	
S13	Std. I.	15-in. 42-lb.	58.9	0.38	21,300	25.8	....	33,000	Lateral deflection of top flange.
S14				0.34	19,300	27.8	....	35,700	
S15				0.37	21,300	27.0	....	35,300	
	Average.			0.36	20,600	26.9	....	34,700	
G16	Girder.	15-in. 73-lb.	118.2	0.45	25,000	26.2	....	42,200	Lateral deflection of top flange.
G17				0.38	21,200	27.3	....	39,600	
G18				0.37	21,200	28.0	....	41,600	
	Average.			0.40	22,500	27.2	....	41,100	
24-in. I-Beams. Quarter-Point Loading. Span, 20 ft.									
B19	Beth. I.	24-in. 72-lb.	174.2	0.39	20,000	26.5	....	32,300	Twist of web.
B20				0.47	25,200	28.7	....	35,500	
B21				0.38	17,500	24.1	....	35,900	
	Average.			0.41	20,900	26.4	....	34,600	
S22	Std. I.	24-in. 80-lb.	173.9	0.43	21,000	23.7	....	33,000	Lateral deflection of top flange.
S23				0.39	20,100	25.5	....	33,000	
S24				0.34	17,500	28.3	....	32,900	
	Average.			0.39	19,500	25.8	....	33,000	
G25	Girder.	24-in. 120-lb.	302.6	0.43	20,100	23.7	....	35,400	Lateral deflection of top flange.
G26				0.25	12,100	26.2	....	33,300	
G27				0.28	14,100	26.8	....	34,400	
	Average.			0.32	15,400	25.6	....	34,300	
30-in. I-Beams. Quarter-Point Loading. Span, 20 ft.									
B28	Beth. I.	30-in. 120-lb.	351.4	0.175	13,000	29.4	....	32,300	Twist of web.
B29					Rejected on surface inspection.				
B30					Rejected on surface inspection.				
	Average.				(Only one beam tested.)				
G31	Girder.	30-in. 175-lb.	523.5	0.18	11,100	25.2	....	27,400	Twist of web.
G32				0.195	10,800	23.9	....	33,000	
G33				0.23	13,400	25.2	....	32,800	
	Average.			0.20	11,800	24.8	....	31,000	

*K = Computed from load at first lateral deflection.
K' = Computed from load at ultimate strength.

NOTE: The chemical composition (from mill records) was within the following range of variation: C 0.18 to 0.26%; Mn 0.41 to 0.86%; P 0.012 to 0.034%; S 0.031 to 0.048%.

A Problem in the Economic Design of Water Distribution Systems.

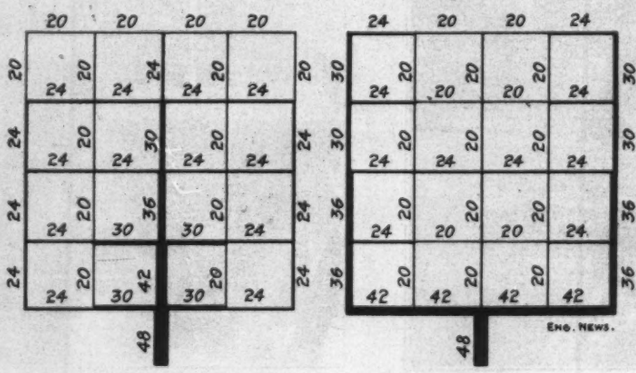
By RUDOLPH HERING.*

[In the design of systems of water distribution, particularly those which are primarily designed for fire-protection purposes, there are two general systems of lay-out which have been used by engineers, and each of them has been strongly defended as the best.

The first of these systems, which has been generally known as the "ring" system, consists, typically, in carrying a large main all around the periphery of the district to be supplied with water. A gridiron of laterals extends from this outside main across the district.

In the other system, a large main is laid through the center of the district, with laterals branching from it to form a gridiron reaching all parts of the territory, and of course with a small main carried around the periphery to eliminate dead ends.

Of these two systems, the ring system undoubtedly appeals to the lay mind as the better. It carries with it the idea of putting a "fortification" or defense all around the area to be protected. On the other hand, the best hydraulic experts contend, and apparently with sound scientific basis, that the system with a central main is the more economical. That is to say, if a given pressure and volume of water is desired all over a certain district, it can be secured at much less cost by laying down a central main with branches; or, to put it another way, if a given amount of money is to be expended, then the system with the central main will give the largest amount of water at the highest pressure.



In view of the discussion in engineering circles over the relative merits of these two systems, it seemed to us worth while to secure an authoritative statement upon this subject from a recognized expert of high standing. We therefore requested Mr. Rudolph Hering, M. Am. Soc. C. E., to furnish us a statement of the reasons why the central-main system is superior. We present Mr. Hering's paper, as follows:—Ed.]

In response to your suggestion, I am pleased to send you a diagram and computation to show the financial importance of a proper and rational consideration of the alinement of the network of a water-distribution system. It is strange that there should still be a doubt concerning it.

About 25 years ago the question of the best alinement came up in Toronto. The superintendent of the water-works had planned to lay a large main all around the city, and to feed towards the center, thinking this was the best arrangement for ample fire protection. I believe I convinced him that precisely the same protection could be obtained in a different way for much less money, because the original plan was not carried out. A few years ago the same question came up in one of our own largest cities, with the same result.

In my report to the National Board of Health in 1881 I stated the principles of alinement with regard to sewerage as I found them practised in Europe. Similar principles can be applied to water-pipe distribution, and the more important ones may be stated as follows:

The pipe system should be designed to deliver at all points a given quantity of water per minute at a given pressure, the quantity being determined by the desired number of fire streams.

To accomplish this object at the least cost, we must consider that:

(1) A pipe carrying twice the quantity of water will cost less than twice as much. Therefore a maximum concentration is economical.

(2) The shorter the distance to which the bulk of the water is carried, the shorter will be the larger pipes, and therefore the less costly the distribution.

(3) The more directly the bulk of the water is delivered to a given point, the less is the friction head, and the greater the remaining available pressure for the same size of pipe, which produces further economy.

It should therefore be endeavored, when making a design, to concentrate the flow and shorten the distance of the bulk of delivery as much as possible. Instead of carrying the water all around the city or district on its periphery, the largest pipes should be laid as nearly as practicable directly to and through the heart or center of the greatest consumption or use for fire purposes.

To illustrate this conclusion graphically, I append two diagrams, one, System A, indicating the alinement I have advocated, and the other, System B, representing the one which I understand you to say some other engineers are advocating. The diagrams show equal areas and are supposed to represent a section of a city requiring a large fire protection. They are divided each into 16 districts or blocks, each block being surrounded by mains at least 20 ins. in diameter, which are shown, and feeding mains placed on streets situated within the block 8 ins. to 16 ins. in diameter, which are not shown. The whole section in each case is supplied by a 48-in. pipe.

The diagrams are prepared merely to illustrate the above-mentioned principles, and are not an actual case. I endeavored to keep every feature the same excepting as to those features the effect of which is to be shown.

System A represents a distribution with concentrated flow, and shortest delivery thereof; System B represents a peripheral distribution.

It must be assumed that outside of the areas of the diagrams no water is to be delivered. It is further assumed that each block is provided with a sufficient fire service if it is supplied by a 20-in. pipe feeding any point at its boundary freely from both directions.

It was the intention to arrange the diagrams so that in both cases a block should be fed at least by an equal number of 20-in. pipes on its sides. As they are drawn, however, there is an undue advantage in economy given to System B. In it two blocks are surrounded on four sides by pipes only 20 ins. in diameter, while in System A no block has 20-in. pipes on more than three sides, the fourth side having a pipe of larger size. Again, in System B five blocks have 20-in. pipes on three sides, while in System A only two blocks have as many as three sides supplied by pipes no larger than 20 ins. in diameter.

If we now enter in the attached table the block lengths for each size of pipe, and indicate the necessary quantities of iron, we find that the distribution pipes for System A require only 4,790 tons of iron, while those for System B require 5,487 tons, or 14.5% more. That is, for every $100,000 expended for iron water mains according to System A, there would be required an addition of $14,500 for System B, without securing for this additional expenditure any advantage whatever, either in pressure or in quantity of water available for a fire at any point.

PLAN A. Block lengths.	Weight of iron, lbs.	PLAN B. Block lengths.	Weight of iron, lbs.
1-42 ins. diam..	588,000	4-42 ins. diam..	4,952,000
1-36 ins. diam..	447,000	4-36 ins. diam..	3,888,000
5-30 ins. diam..	1,660,000	4-30 ins. diam..	3,328,000
19-24 ins. diam..	4,408,000	10-24 ins. diam..	8,320,000
14-20 ins. diam..	2,478,000	18-20 ins. diam..	4,186,000
Total	9,581,000	Total	16,974,000

Percentage of excess of iron in B over A = 14.5%.

If a block length of one of the largest mains should be put out of service by accident, and should a conflagration then occur at any point, a proper equipment of shut-off gates being assumed, the two systems are about alike in the quantity of water which would then be delivered.

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Notes on Shrinkage of Earthwork and on Steam Shovel Work.*

By F. PARDOE WILSON,†

This paper is compiled from notes made by the writer while Resident Engineer of Construction for the Canadian Pacific Railway Grade Reduction and Revision, Medicine Hat Section, 1907-8.

SHRINKAGE.—The first question that comes up in this connection is, "What is the contractor to be paid for?"

On light prairie work embankment quantities are often taken, and, considering the practical impossibility of accurately measuring shallow borrow pits as left by the generality of contractors and sub-contractors, it would seem to be the most accurate method. If, however, work is paid for from cut quantities, to be rational, all borrow pits must be staked and measured. The practice of paying for cuts up to limit of haul and balance on embankment quantities is not logical.

In the case of excavation quantities, the question of shrinkage is not a live one with the contractor, but the reverse is the case when embankment is paid for.

A method of applying shrinkage is required to be sufficiently elastic to meet the variety of conditions met with in the field, and at the same time sufficiently exact to do justice as between the company and the contractor. This question is often a bone of contention between them on account of the magnitude of the quantities involved being overlooked.

On side-hill ground, and when cuts and fills alternate rapidly and are of considerable extent, the theoretical shrinkage, if applied on top, would lead to anomalous conditions. When track laying has closely followed construction, cases are not unknown where the top shrinkage applied has had to be removed, or where, as illustrated in Fig. 4, the shrinkage, if not immediately taken up by settlement, might exceed the permissible grade.

From these considerations it would appear reasonable to omit raising the fill above profile grade and applying side shrinkage only to make a full shoulder so as to carry the material required to make up to grade as bank settles.

Fig. 1 shows the usual method of applying shrinkage, while Figs. 2 and 3 show modifications of this method according as to whether or not excess quantities are permissible, or whether or not it is thought desirable to steepen the side slopes.

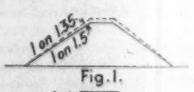

Fig. 1.

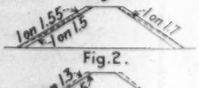

Fig. 2.

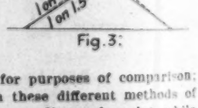

Fig. 3.

Setting the slope stakes 1 on 1.3, 1.4, 1.6 or 1.7 instead of the customary 1 on 1.5 is easily done in the field by adding or subtracting 1/10 or 2/10 for every foot in height of fill to the 1 on 1.5 half breadths.

Tables II.-IV. are inserted for purposes of comparison; the quantities being based on these different methods of applying shrinkage (figured to profile grade only) while the actual percentage increase from the standard roadbed and side slopes is stated.

To provide the full shoulder (always desirable), the width required at profile grade from considerations of height of fill at that point (Fig. 4) is taken, reduced for practical purposes to the nearest foot and slope stakes set in accordance with Fig. 2 or 3.

This representation in the cross-section notes (Table I. and Fig. 4) of the quantities to profile grade represents the cross-sections as they are staked without additions or alterations, and avoids complication and consequent chances of error in figuring the quantities. It gives a definite and straightforward basis to work on.

*Portion of paper read before the Canadian Society of Civil Engineers, April 15, 1909.

†Resident Engineer, Canadian Pacific Ry., Winnipeg, Man.

TABLE I.—SHOWING DATA OF PROFILE IN FIG. 4.

Section.	Top shrinkage.	Width at profile grade from top shrinkage.	Height of fill.	Width at profile grade from height of fill.	Practical width at profile grade.*
a	0.33	17.0	6	17.8	18
b	0 67	18.0	10	19.0	19
c	1.00	19.0	14	20.2	20
d	1.33	20.0	16	20.8	21
e	1.67	21 0	18	21.4	21
f	2.00	22.0	20	22.0	22
g	2.00	22.0	20	22.0	22
h	1.75	21.25	17	21.1	21
i	1.50	20.5	15	20.5	21
j	1 25	19.75	12	19.6	20
k	1.00	19.0	10	19.0	19
l	0.75	18.25	5	17.5	18
m	0.50	17.5	2	16.6	17
n	0.25	16.75	1	16.3	16

*Used in cross sectioning as per Fig. 3, or in figuring quantities and setting second grades as per Fig. 2. Note discrepancies between columns 3 and 5.

and enables another man to pick up one's notes and follow what has been done.

In paying for embankment quantities if an arbitrary classification of shrinkage is adopted, such as:

Team and slip work	Nil
Wheeler and wagon work	5%
Dumpcar and wheelbarrow	10%

and from a considerdtion of the fact that earth, when first moved by these several methods, expands about that same percentage it would appear that the old expedient of putting on shrinkage and paying for neat embankment quantities is not very wide of the mark after all.

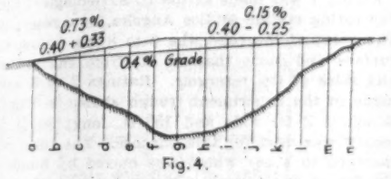

Fig. 4.

STEAM SHOVEL WORK.—Fig. 5 will be found useful in determining what a given size of shovel will do, and enable one to lay out the most economical lifts which should be taken in making a thorough cut.

The question of water supply for the shovel, its quality and quantity, should never be overlooked, as it materially affects the cost of the work.

The use of heavier rail than the dinkeys and dumpcars call for is not economical, as it costs too much to move around and handle.

An all-around shovel on traction wheels with a 1½ or 2-yd. dipper, and 2½-yd. cars on 30-lb. rails, would often be more serviceable than the heavier types of shovels, where the frequency and distance of moves is considered, and if it could be operated by a gasoline motor to solve the fuel difficulty, an almost ideal machine for railway work would be available.

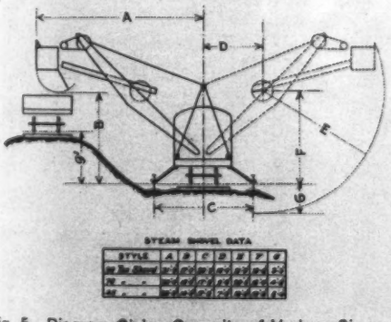

Fig. 5. Diagram Giving Capacity of Various Sizes of Steam Shovels.

TABLE IV.

Fill.	Slopes.	Roadbed for X section and setting stakes.	Cu. yds.	Nominal shrinkage 5% Fig. 3 cu. yds.	Actual-percentage increased quantities over 16-ft. roadbed 1 on 1.5.
10	1.4	17.5	1,166	18	1%
20	..	19.0	3,481	74	2%
30	..	20 5	6,944	166	3%
				10% Fig. 3	
10	1.3	19	1,185	37	3%
20	..	22	3,555	148	4%
30	1.3	25	7,111	333	5%

A Reinforcing Bar of Varying Section.

By ELI WHITE.*

All engineers familiar with the design of steel bridges are acquainted with the practice of proportioning the chords of trusses and flanges of girders so that the maximum unit stresses shall be approximately constant throughout the length of the bridge. This is accomplished by using the maximum section at the center of the span and decreasing the section of the chords or flanges in proportion to the decrease in moment. This principle has been used somewhat heretofore in the design of reinforced-concrete beams, but has been specifically applied to the construction of the reinforcement described herewith. The bar which has been developed and patented by the writer not only gives the maximum possible economy of steel for resisting both shear and tensile stresses, but also furnishes a reinforcement which can be shipped or stored as readily and in as small space as ordinary straight bars.

The bar, as shown in Fig. 1, is composed of a number of flats, which may vary in size from 1 × ⅛ in. to 1½ × 3-16 in. The flats are bound together by clamps, which may conveniently be ½ × ⅛ in. and these are welded to the bottom bar and are bent around the longitudinal bars as shown in section. For shipping and storage the bar is as shown in Fig. 2. When required for use, the ends are bent diagonally upward as shown in Fig. 1 and if the shearing stresses to be resisted are large, the ends may be bent as shown by dotted lines to give increased bond.

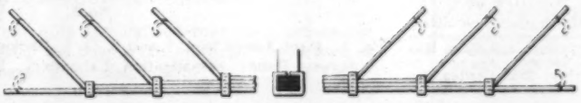
FIG. 1. ELEVATION OF THE WHITE REINFORCING BAR IN THE BEAM.

Economy of steel is secured by bending up successive bars at intervals proportionate to the decrease in moment. On account of this, the unit stress in the horizontal portion of the bar is approximately constant for the entire length and maximum efficiency of steel is secured with minimum weight. The saving in steel attained by this form of bar varies from 15 to 40%. For beams of 16 to 20 ft. span with a uniform load, 25% less steel is required than would be needed using loose rods with vertical stirrups. A saving as great as 40% can be made on beams having a concentrated load at the center, as the decrease in moment is most rapid for this type of loading.

In order to determine whether such a saving in steel could be made with safety, six T-beams were made, having respectively the dimensions and reinforcements shown in Fig. 3, and were tested at Swarthmore College during the present year. The tests were made by Messrs. A. B. White and G. N. Ash under the direction of Professors G. F. Blessing and S. S. Garrett, of the engineering department. The loads were applied at the third points as indicated by arrows. The concrete was the same for all beams, being a 1:2:4 mix of cement, coarse bar sand and ¾-in. crushed limestone. The beams were tested 60 days after making. The steel used in both forms of reinforcement was medium steel. Numerous tests showed the elastic limit of the corrugated bars to be 41,600 lbs. per sq. in., and that of the flat bars to be 45,400 lbs. per sq. in. The respective weights of reinforcements as given in the figure are actual scale weights.

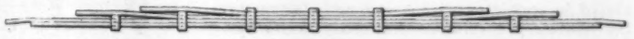
FIG. 2. THE WHITE BAR PACKED FOR SHIPPING.

The elastic limit of beams I., II. and III. was reached at a load of 13,000 lbs., while the load at elastic limit for beams IV., V., VI. was 16,000 lbs. From this it appears that with 15% less metal, beams IV., V. and VI. had an elastic limit 14% above beams I., II. and III., even after making due allowance for the difference in elastic limit of the steel.

The results of the tests show that a saving in steel may be made in concrete beams in the same way as is done in the flanges of plate girders. It was noticed that there were no indications of failure near the supports, proving that horizontal reinforcement is not required near supports to prevent shear failures, if the diagonal tension is properly cared for by diagonal shear members.

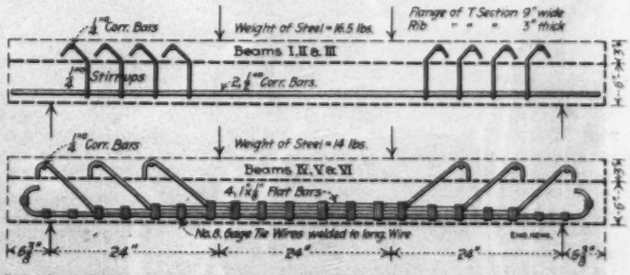

FIG. 3. DETAILS OF REINFORCED-CONCRETE BEAMS TESTED AT SWARTHMORE COLLEGE.

The welding of the clamps to the bottom bar accomplishes two purposes. First, it permits the bar to be shipped flat with absolute certainty as to the location of shear members when the ends are bent upward in the field; second, the clamps furnish a strong mechanical bond between the concrete and the steel. With the present development of electric and acetylene welding, the clamps can very readily be welded to the longitudinal bar.

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TABLE II.

Fill Ht. in ft.	Slopes.	Roadbed.	Cubic yards.	5% Fig. 1 cu. yds.	Slopes.	Actual %.	10% Fig. 1 cu. yds.	Slopes.	Actual %.
10	1.5	16	1,148	28	1.425	2	55	1.35	5
20	1.5	16	3,407	111	1.425	3	222	1.35	6
30	1.5	16	6,778	250	1.425	4	500	1.35	7

TABLE III.

Fill Ht. in ft.	Slopes.	Roadbed for setting stakes.	Roadbed used in figuring X sect.	Cubic yards.	Nominal shrinkage 5%—Fig. 2 cu. yds.	Actual percentage increased quantities over a 16-ft. roadbed 1 on 1.5.
10	1.6—1	16	17.5	1,185	30 + 37 = 67	6%
20	.....	..	10	3,555	118 + 148 = 266	8%
30	.....	..	20.5	7,111	266 + 333 = 599	9%
					10% Fig. 2	
10	1.7—1	16	19	1,222	63 + 74 = 137	12%
20	.....	..	22	3,708	252 + 296 = 548	16%
30	.....	..	25	7,444	566 + 666 = 1,232	18%

THE LEAK IN THE WELLAND CANAL noted in our issue of July 29, p. 131, was not as serious as there reported. A small but dangerous leak opened up through one of the banks and necessitated the drawing out of the adjacent level for two days. An ambitious reporter magnified this into the phrase "Banks on both sides of the canal were washed away for a considerable distance."

Ratings of a Pitot Tube.*

By E. C. MURPHY,† M. Am. Soc. C. E.

Velocity measuring tubes, although having points of various shapes, are generally called "Pitot" tubes, after the name of the man who, with one of his own invention, first successfully measured velocity below the surface of a stream of water. Their action depends on the well-known law of hydraulics that velocity is proportional to the square root of the head which it produces.

This instrument consists essentially of two tubes, one terminating in an orifice pointed up-stream, so as to receive the impulse of the water, the other with an orifice either pointed at right angles to the direction of the current to indicate static head, or pointed down-stream so as to indicate negative impulses or suction. For convenience in reading the height of the columns, glass tubes are connected to these tubes, between which is a reading scale, and the air over the columns of water is partly exhausted to bring the top of each column in a suitable place. A valve is placed in each pipe with a common closing lever for holding the columns stationary while being read. A mirror back of the scale enables the eye to be properly placed to read the scale. If the scale is placed in an inclined position the column difference is lengthened and the error in reading reduced.

The tube whose ratings are here discussed is used in the U. S. Geological Survey debris-investigation laboratory for the measurement of the velocity of small, shallow, open-channel streams. It is called Tube No. 3, and is illustrated by Figs. 1, 2 and 3. It is a development of Tube No. 1, shown in Fig. 1. The small sizes of sand carried by the water clogged the impulse opening of No. 1 and the air creeping down the back of it entered the suction opening at the higher velocities.

*Data used with permission of Director and Chief Hydrographer of the U. S. Geological Survey.

†Engineer, U. S. Geological Survey, 2338 Carlton St., Berkeley, Cal.

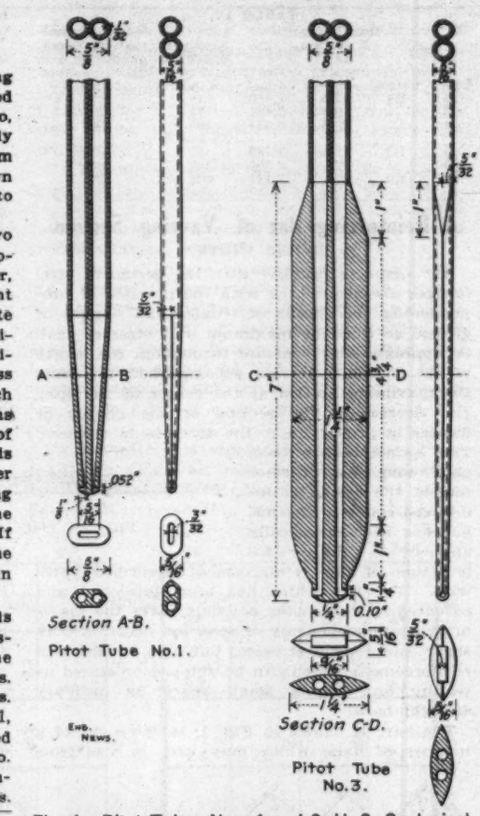

Fig. 1. Pitot Tubes Nos. 1 and 3, U. S. Geological Survey Debris Investigation Laboratory, Berkeley, Cal.

The water in the rear of No. 3 will stand half an inch or more higher than in front, instead of a depression forming in the rear, as was the case with No. 1. The construction of these tubes is shown in Figs. 1 and 2, so that description is unnecessary.

Tube No. 3 has been rated five times, four times in still and once in moving water. The column difference for each half foot of velocity for these ratings is given in Table I.

TABLE I.—VELOCITY AND COLUMN DIFFERENCE[a] FOR RATINGS OF TUBE NO. 3.

Velocity, sec. ft.	Rated in reservoir	Rated in trough; tube point near			Rated in moving water.
		Bottom[a]	Mid depth[b]	Surface[c]	
1.5	1.45	1.44	1.32	1.25	1.55
2.0	2.48	2.67	2.50	2.25	2.85
2.5	3.95	4.12	3.90	3.48	4.50
3.0	5.75	5.80	5.53	4.95	6.35
3.5	7.90	7.73	7.43	6.71	8.30
4.0	10.35	9.90	9.63	8.80	....
4.5	13.00	12.55	12.15	11.28	....
5.0	15.70	....	....	....	....

[a]Column scale has an inclination of 2.5 horizontal to 1 vertical.

[a]Depth water, 0.45 ft. Point of tube held 0.02 ft. above bottom.

[b]Depth water, 0.45 ft. Point of tube held 0.25 ft. above bottom.

[c]Depth water, 0.44 ft. Point of tube held 0.03 ft. below surface.

Rating 1 was made at the U. S. Geological Survey rating station at Los Angeles, in a reservoir. The point of the tube was 6 to 8 ins. below the surface and more than 10 ft. from the bottom and sides of the reservoir. Ratings 2 to 5 were made in the experiment trough shown in Fig. 3, which is 2 ft. wide and 150 ft. long; 80 ft. of length was used for this purpose. The tube was fastened to a car which was moved by hand on the top of this trough. Rating 5 was made in a trough 1 ft. in width and the tube was held at from 21 to 35 places in the cross-section of measurement in each experiment.

THE RESERVOIR RATING.—The velocity and corresponding column difference (the sum of the impulse and suction heads) are plotted in Fig. 4.

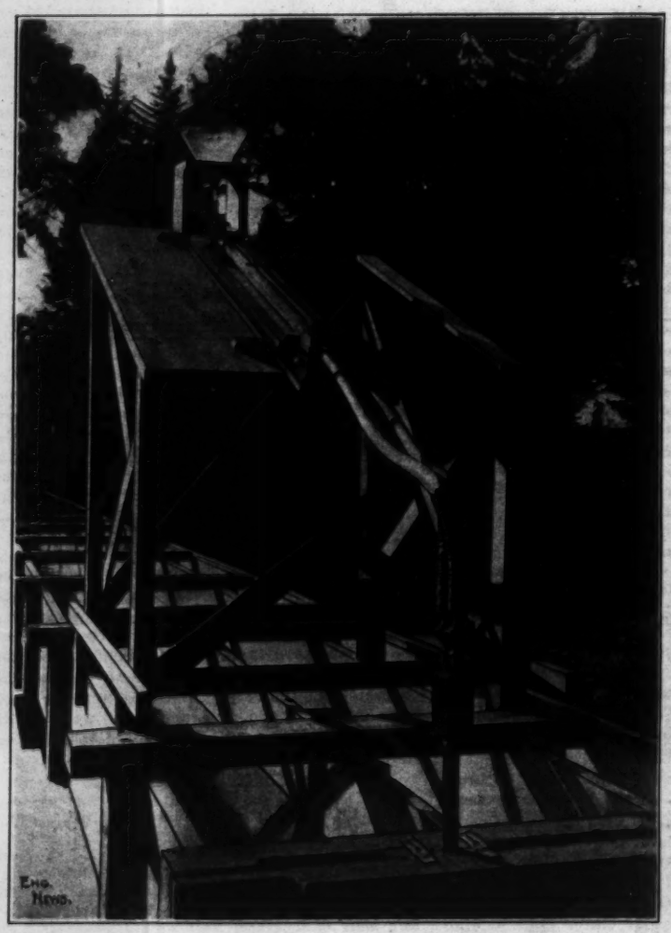

FIG. 2. VIEW OF PITOT TUBE, U. S. GEOLOGICAL SURVEY DEBRIS INVESTIGATION LABORATORY, BERKELEY, CAL.

FIG. 3. TROUGH FOR TESTING PITOT TUBE NO. 3, BERKELEY, CAL.

From the curve of this figure the velocity corresponding to each inch of column difference was taken and the coefficient C in the equation $V = C\sqrt{2gl}$ computed, (V = velocity in ft. per sec.) g = the acceleration of gravity in ft. per square second and l is the difference of the column readings in inches, the scale having an inclination of 2.5 horizontal to 1 vertical. The value of C varies from .156 to .159, the mean being .157 for velocities from 1.28 to 5.00 ft. When the column difference is expressed in feet, $C = .544$; when expressed in feet of vertical height, $C = .89$; and when expressed in vertical height for either impact or suction singly (Fig. 5), $C = 1.26$.

RATINGS IN SHALLOW, STILL WATER.—A study of ratings 2—4 shows that there is a gradual decrease in the column difference "l" for any velocity of the tube as the point of the tube is moved upward from the bottom. For example, when the velocity is 3 ft. per sec., "l" is 5.80 ins. when the tube point is held near the bottom, 5.53 ins. when held near mid depth, and 4.95 ins. when held near the surface. The value of C for this tube depends on the distance of the point from the trough bottom.

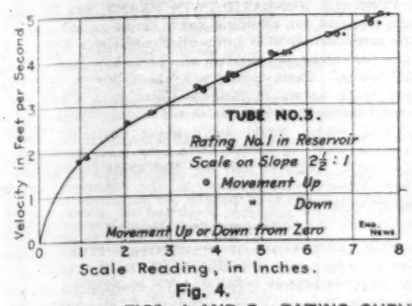

Fig. 4.

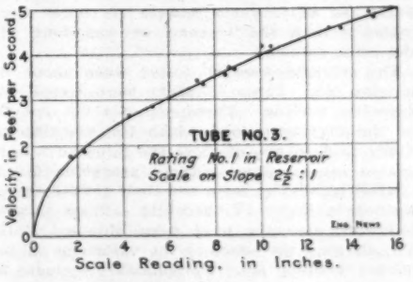

Fig. 5.

FIGS. 4 AND 5. RATING CURVES FOR PITOT TUBE IN RESERVOIR.

RATINGS IN MOVING WATER.—The data obtained from this rating are condensed in Table II.

TABLE II.—RATINGS OF TUBE NO. 3 IN MOVING WATER. TROUGH WIDTH, 1 FT.

Depth water, ft.	Discharge, sec. ft.	Column difference, ins. (a)	Mean velocity, By discharge & cross-section, Vm.	Mean velocity, by (b) Tube, Vt.	Vt—Vm. Vm. in %.
.288	.923	7.00	3.21	3.40	6.0
.246	.784	6.34	2.98	3.21	7.7
.198	.545	5.72	2.75	3.05	10.9
.154	.363	4.14	2.35	2.58	9.8
.370	.734	2.65	1.98	2.04	3.0
.418	.734	2.19	1.75	1.86	5.1
.606	.923	1.58	1.53	1.57	2.6

(a) Column scale has an inclination of 2.5 horizontal to 1 vertical.
(b) Computed from rating with tube point at mid depth.

The velocity as found from the tube rated in still water is seen to be from 2.6% to 10.9% greater than that computed from discharge and cross-section, and this difference increases as the depth decreases. In other words, the velocity as found by this tube from the still water rating is from 2.6% to 10.9% greater than found from the moving-water rating.

The following important conclusion may be drawn from these ratings: Pitot tubes should be rated in moving water, and the range of depth of water used in the rating should be about the same as that to be measured.

THE COST OF CONTACT BEDS AND PERCOLATING filters, at Sutton, Surrey, is compared as follows in a paper by Mr. C. Chambers-Smith, Engineer and Surveyor to the Urban District Council, read at a meeting of the Associations of Managers of Sewage Disposal Works, at Sutton, in June, 1909:

It will be seen that the results from the continuous percolating filter are much superior to those from the double contact beds, while the cost of construction of the latter as carried out at the low-level works where the beds are charged twice per day is much higher. The cost brought down to a standard of 1,000 gals. is as follows—viz.:—

Cost of construction of contact beds per 1,000 gals. treated	14£
Cost of construction of percolating filter per 1,000 gals. treated	6£

The effluent from the percolating filter has been continuously of uniform character.

Crushing Tests of Brick and Terra-Cotta Piers at Illinois Engineering Experiment Station.

The Illinois Engineering Experiment Station recently made a series of compressive tests on piers of brick and terra-cotta. While small in number, they are specially interesting because care was taken to vary the several possible factors of strength, so as to get definite information as to the influence of these factors. They are reported in full in a pamphlet of the Station (Bulletin No. 27) by Prof. A. N. Talbot and Mr. D. A. Abrams, from which we abstract the following summary.

Brick Columns.

Sixteen columns were tested. Two of these were built of a soft, underburned brick, poorer than would ordinarily be used in building, while the other 14 were all of a uniform grade of selected hard brick. It happens that the hard bricks were made of shale and the soft ones of clay, but it is not claimed that their differences in quality are due to the material; the degree of burning is alone responsible.

The size of the bricks averaged:

Hard bricks: 2.35 × 3.95 × 8.25 ins.

Soft bricks: 2.40 × 4.05 × 8.20 ins.

Their crushing strengths, tested flatwise, bedded in plaster of paris, averaged 10,700 and 3,900 lbs. per sq. in. respectively. Tested in cross-breaking edgewise, 6-in. span, the average modulus of rupture was in about the same ratio for the two kinds, i. e., 1,670 lbs. per sq. in. for the hard brick and 480 lbs. for the soft brick.

The bricks were laid up in square piers or columns 1½ brick square (about 12½ × 12½ ins) and about 10 ft. high, with a 1¼-in. cast-iron plate at bottom and top. The soft brick were plunged in water a few minutes before laying. An experienced bricklayer hired from a local contractor laid up the columns. His workmanship is described as average, but it appears that the vertical joints were filled thoroughly. At any rate, under special instructions, two of the columns were laid up more hurriedly, with "less care in making horizontal joints and in filling the vertical joints." These were built in a fourth less time than the others, and actually they proved to be weaker in the tests.

The columns were left in vertical position as laid up, and when ready for test were kept upright while being transported to the machine. The room temperature during storage was 55° to 70° F., and the mortar was permitted to dry out freely.

Fourteen columns were tested at 2 months, and two at 6 months.

The tests were made in the 300-ton vertical screw Riehlé machine of the University of Illinois laboratory. This machine has side posts which brace the top head laterally, so that in compression tests the top of the test-piece is held against deflecting sidewise. It was therefore possible to make satisfactory tests under eccentric loads.

For central loading, a spherical head was used. For eccentric loading (1-in. eccentricity), a ½-in. square steel bar was placed between the cast-iron bearing plate and the machine head on the line of loading.

Longitudinal compression was measured on a length of 100 ins., on two opposite sides of the column.

RESULTS.—The features of the individual tests of brick columns and the results, are given in Table I. herewith. These results are classified as to characteristics of the test-pieces in the following summary:

TABLE II.—SUMMARY OF BRICK COLUMN TESTS.

All columns 12½ × 12½ ins. nominal, about 10 ft. long. Tested at the age of 63 to 69 days, except where noted.

Column Characteristics. (Mortar, Age, Loading, Workmanship, Kind of Brick.)	Ultimate crushing strength Lbs. per sq. in.	Ratio to first of series.	Ratio to strength of Single brick.	Ratio to strength of Mortar cubes.
1:3 Portland, *well laid* (3 tests)	3,365	St'd	0.31	1.17
1:3 Portland, *hurriedly laid* (2 tests)	2,920	0.87	0.27	1.05
1:3 Portland, *six months** (2 tests)	3,950	1.18	0.37	....
1:3 Portland, *eccentric loading* (2 tests)	2,800	0.83	0.26	....
1:3 Portland, *soft brick* (2 tests)	1,060	0.31	0.27	0.37
1:5 *Portland* (2 tests)	2,225	0.66	0.21	1.30
1:3 *Natural* (1 test)	1,750	0.52	0.16	5.75
1:2 *Lime* (2 tests)	1,450	0.43	0.14	....

*One of these two columns did not fail at maximum capacity of machine but failed at 7th repetition of this load, = 4,110 lbs. per sq. in.

It appears, therefore, that brickwork gains strength by (1) stronger brick, (2) stronger mortar, (3) age (in case of Portland cement), and (4) careful work on the part of the bricklayer.

The one test under repeated loading also exhibits the well-known fact that if a load near the ultimate strength is repeated several times, the test-piece, becoming weaker at each repetition, finally fails under the same (or lower) load that it previously carried without apparent distress.

These results are nothing more than would be expected. A new result of some interest, however, is contained in the last two columns of the summary, where are given the ratios of pier strength to strength of brick and mortar respectively. There is no regularity about these ratios, i. e., neither the brick strength nor the mortar strength fixes the strength of pier. The best conclusion is that the mortar (which is always much weaker than the brick) has a greater

TABLE I.—TESTS OF BRICK COLUMNS.

Column characteristics.	Mortar.	Age at Test, days.	Ultimate load. Total, lbs.	Ultimate load. Lbs. per sq. in.	Load-ratio at which sound was heard.	Initial modulus of elasticity, lbs. per. sq. in.	Manner of Failure.
A.—Hard-burned shale brick.							
Well laid, central load	1:3 Port.	66	507,000	3,220	0.50	4,350,000	Split top to bottom.
Well laid, central load	"	68	537,000	3,510	0.60	5,450,000	Collapsed suddenly.
Well laid, central load	"	65	527,000	3,370	0.50	4,550,000	Collapsed suddenly.
Well laid, central load	"	181	601,000	3,790	0.75	4,700,000	Collapsed suddenly.
Well laid, central load	"	181	651,000*	4,110*	....	5,350,000	Upper half shattered.
Hurriedly laid, central load	"	69	454,000	2,860	0.66	3,550,000	Collapsed suddenly.
Hurriedly laid, central load	"	68	462,000	2,980	0.65	3,500,000	Middle thrown out.
Well laid, eccentric load (1 in. ecc.)	"	69	427,000	2,720	0.71	4,100,000	Split near top.
Well laid, eccentric load	"	67	452,000	2,880	0.52	4,700,000	Split, middle thr'n out.
Well laid, central load	1:5 Port.	66	350,000	2,190	0.57	3,500,000	Split bottom to top.
Well laid, central load	"	65	358,000	2,260	0.48	3,000,000	Split and collapsed.
Well laid, central load	1:3 Nat.	66	277,000	1,750	0.40	800,000	Spalled at joints.
Well laid, central load	1:2 Lime.	67	216,000	1,360	0.38	101,000	Spalled. Joints crushed.
Well laid, central load	"	66	248,000	1,540	0.48	107,000	Deflected to one side, spalled and crushed on opp. side.
B.—Underburned clay brick.							
Well laid, central load	1:3 Port.	63	166,000	1,030	0.91	435,000	Collapsed.
Well laid, central load	"	62	177,000	1,090	0.62	430,000	Collapsed

Note.—All columns had nominal section 12½ × 12½ ins.; actual sections varied from 153.0 to 161.9 sq. ins. Lengths varied from 9 ft. 8½ ins. to 10 ft. ¼ in. Number of courses varied from 40 to 43. Average thickness of mortar joint varied from 0.30 to 0.46 in.
*Repeated load. Broke on seventh repetition.

influence on the strength of the brickwork than does the crushing strength of the brick itself.

The piers nearly all cracked longitudinally before failure, and the failure was a direct consequence of this splitting. The cracks followed down through one of the two lines of vertical joints, the crack going straight through joint and solid brick. The first evidence of cracking was "a faint popping sound which seemed to proceed from the interior of the column." At higher stages of loading louder sounds were heard; the visible cracks appeared only shortly before the maximum load, when the mortar also began to spall off at the corners.

The cracks generally were confined to the upper part of the pier. The mortar in the lower part was stronger because it had set under the load of the superincumbent brickwork, and this may account for the localization of the cracks, although the mortar in the vertical joints was probably not affected by this strengthening action.

Watertown Brick Columns.

The Illinois piers, while they make an excellent showing, are not as strong as can be built, however. Higher strengths were reported some time ago by Mr. J. E. Howard from the Watertown Arsenal test records. He selected from a large number of brick-pier tests those showing strengths over 3,000 lbs. per sq. in. (15 different tests). Grouping these according to kind and age of mortar, they yield the following summary.

TABLE III.—HIGH-STRENGTH BRICK PIERS FROM WATERTOWN TESTS.

All piers 12 × 12 ins. nominal, 8 ft. high. Bricks from different makers used, but each pier contained only one make of brick. All piers laid up in Portland cement mortar.

Column characteristics. (Mortar, age.)	Ultimate strength, lbs. per sq. in.	Modulus of elasticity, betw. loads of 600 and 1,000 lbs. per sq. in.
Neat cement, 2—7 days (4 tests)	4,520	3,720,000
Neat cement, 1—6 months (6 tests)	4,460	3,233,000
1:2 cement, 2½ months (1 test)	3,775	2,780,000
1:3 cement, 6 months (1 test)	3,440	1,923,000
1:5 cement, 8—9 months (3 tests)	3,245	2,430,000

The strongest pier of this series was one laid up with neat cement and tested at 7 days, which gave a strength of 5,600 lbs. per sq. in. The series also shows that, broadly speaking, the strongest piers have the highest modulus of elasticity. The highest in the list, 5,128,000, belongs to a pier which had a strength of 5,000 lbs. per sq. in.; the next, 4,444,000, belongs to the strongest pier of the series, with 5,600 lbs. ultimate strength.

It appears that the above Watertown results do not exhibit any such marked differences as Prof. Talbot's tests. But this is doubtless primarily due to the care taken by Prof. Talbot to keep all factors constant except those which were specifically varied.

Terra-Cotta Columns.

Sixteen columns were tested. Their size varied from 8½ × 8½ to 17½ × 17½. The blocks themselves were 4 × 8½ ins. by 8 ins. high, with three longitudinal holes, two 1½ × 1½ ins. and one ½ × 1½ ins. The blocks are assumed to have been a picked lot. They were all from one maker, but came in two shipments, which showed slight differences of shape whose influence was seen in the results. The blocks of the first shipment had markedly concave end-faces, while those of the second lot had nearly flat ends. The former gave lower results both in the single block tests and in the column tests.

The endwise crushing strength of single blocks averaged 3,472 lbs. per sq. in. (gross area) for the first shipment, and 5,170 lbs. per sq. in. for the second shipment. Tested in flexure on end, span 7 to 8 ins., load at center, the modulus of rupture computed for the net section averaged 1,020 lbs. per sq. in.

The columns built with blocks of the first shipment (Cols. 1-7) were laid up by a workman sent by the company which furnished the blocks. The nine columns of the second shipment were built by the bricklayer who built all the brick columns, a man who had had no experience in terra-cotta. No attempt was made to fill the holes in the blocks with mortar. Three columns were built under special instructions to hurry, so as to get a sample of poorer workmanship than the average, as was done with the brick columns.

The columns were all tested when about two months old. Three of them were tested with eccentric loading. Three columns did not fail at the maximum load which the machine can apply, and on two of these the full load was repeated several times without producing failure.

RESULTS.—The tests and their results are described in Table IV. herewith. From this the following averages have been obtained (Table V.), showing the effect of the variations in size, mortar, loading, etc. The summary includes the entire first series (concave-end blocks) as a single item; for, while the cross-section was varied in the first series from 8½ ins. square to 17½ ins. square, no effect of this can be detected.

TABLE V.—SUMMARY OF TERRA-COTTA COLUMN TESTS.

(All columns 12½ × 12½ ins. nominal, about 9¾ ft. long. Made from blocks of second shipment except where noted "concave-end blocks." All tested at 2 months.)

Column Characteristics. (Mortar, Loading, Workmanship, kind of blocks.)	Ultimate crushing strength: Lbs. per sq. in.	Ratio to first of series.	Ratio to strength of: Single block.	Mortar cubes.
1:3 Portland, *well laid* (2 tests)	4,300†	St'd	0.83	1.26
1:3 Portland, *hurriedly laid* (1 test)	3,305	0.76	0.64	1.05
1:3 Portland, *eccentric loading* well laid (1 test)	3,470	0.81	0.65	1.12
1:3 Portland, *hurriedly laid* (1 test)	3,110	0.75	0.60	1.06
1:3 Portland *underburned blocks** (1 test)	3,050	0.71	0.59	0.88
1:5 *Portland* (2 tests)	3,350	0.78	0.65	....
Concave-end blocks 1:2 Portland (6 tests)	2,970	0.69	0.86	....

*Blocks from second shipment, all of which were of good quality. Enough blocks that appeared somewhat underburned or otherwise inferior were selected to make up one column.
†Estimated.

The general showing of this summary is the same as that of the brick column tests. That is to say, distinct weakening is shown to result from poor quality of blocks, leaner mortar, eccentric loading and careless workmanship.

Special attention is due the results of the concave-end block columns compared with the flat-end block columns. Though the former were made with richer mortar, yet their strength is 30% less. The concavity of the ends of the individual blocks doubtless subjects the blocks to greater bending effect, because the bearing pressure would tend to concentrate at the high points of the end faces. Also, the mortar at these points would be subjected to more than the average pressure. This would naturally weaken the pier, but so great a weakening as 30% is rather unexpected. The importance of getting blocks with good square ends is evident.

The phenomena of failure of the terra-cotta columns were similar to those observed with the brick columns, except that the "popping" sounds occurred only shortly before the maximum load. Very soon after these sounds were heard, longitudinal cracks appeared, or else the mortar spalled at the ends of the joints. A short time afterward the column failed very suddenly, and generally smashed up quite thoroughly.

TABLE IV.—TESTS OF TERRA-COTTA COLUMNS.

(All columns tested at age of 63 to 69 days.)

Column Characteristics.	Nominal section, ins.	Length, ft. & ins.	Mortar.	Ultimate Load: Total lbs.	Ultimate Load: lbs. per sq. in.	Initial modulus of elasticity, per sq. in.
A.—Blocks of First Shipment (concave ends). Tested January, 1907.						
Well laid, central load	8½ × 8½	12— 6	1:2 Port.	219,000	3,030	2,170,000
Well laid, central load	8½ × 8½	12— 6¼	"	200,000	2,740	1,910,000
Well laid, central load	8½ × 13	11—11	"	300,000	2,700	....
Well laid, central load	8½ × 13	11—10½	"	388,100	3,440	2,150,000
Well laid, central load	13 × 13	12— 7¼	"	543,400	3,200	2,040,000
Well laid, central load	13 × 13	12— 7	"	458,000	2,710	2,700,000
Well laid, central load	17½ × 17½	12— 7¾	"	†607,700	†1,980	2,200,000
B.—Blocks of Second Shipment (flat ends). Tested January, 1908.						
Well laid, central load	12½ × 12½	9— 9	1:3 Port	†606,000	†3,730	2,780,000
Well laid, central load	12½ × 12½	9— 9	"	†616,000	†3,790	2,750,000
Well laid, eccentric load	12½ × 12½	9— 9	"	565,000	3,470	2,330,000
Hurriedly laid, central load	12½ × 12½	9— 9	"	538,000	3,330	2,860,000
Hurriedly laid, eccentric load	12½ × 12½	9— 9	"	501,000	3,110	2,500,000
Hurriedly laid, central load	12½ × 12½	9— 9	"	534,000	3,280	3,200,000
Well laid, inferior blocks,* central load	12½ × 12½	9— 9½	"	500,000	3,050	2,300,000
Well laid, central load	12½ × 12½	9—10	1:5 Port.	526,000	3,200	2,680,000
Well laid, central load	12½ × 12½	9—10	"	564,000	3,500	2,700,000

*Enough underburned or otherwise inferior appearing blocks were selected to make up one test column. The entire shipment, however, was of good quality.
†Did not fail. Set aside for future test.

TUNNELS BENEATH TWIN PEAKS, San Francisco, are proposed for affording quick access to and aiding in the development of a large area comprising some 12 sq. mi., or about a quarter of the whole area of San Francisco. These peaks are about 900 ft. high, and bar ready access to residence sites in a hilly, wooded area, sheltered from the ocean winds. Plans for the tunnel, which would begin about Castro St. and be some 7,700 ft. in length, have been made by Mr. H. A. Campbell, Engineer for the Merchants' Association of San Francisco, according to the "Review" of that organization for July, 1909.

THE CONDITION OF CREOSOTED PILES 25 years old is reported in a letter by Mr. G. E. Verrill, U. S. Assistant Engineer, reprinted in Professional Memoirs, Engineer Bureau, U. S. Army, v. 1, No. 3, July-Sept., 1909. The piles in question are in sea-water and are a part of the Sandy Point Dike across Fore Hale Bar, near New Haven, Conn. They were treated by the Full Cell Process of creosoting with dead oil of coal tar and driven from 1883 to 1886. Mr. Verrill's letter says:

Originally the plan called for two rows of creosoted piling, 8 ft. apart, filled in with stone. The outer portions of the shore-arm, 846 ft. long and 25½ ft. at the north end of the channel-arm, were built of the creosoted piling. The piles composing the shore-arm vary from 7 ins. to about 9 ins. in diameter at the exposed end, while those on the channel-arm seem to run somewhat larger (from about 8 to 10 ins. in diameter) and were apparently better piles in the beginning. All of the piles are driven quite close together, but not as a rule in absolute contact. Generally speaking, the condition of the piles is good, particularly those in the channel-arm, most of these being in remarkably good condition, so that not over 5% in this portion of the dike are seriously impaired, and many are apparently in as good condition as when they were first driven. In the shore-arm the conditions are not as good, although the greater number of the piles are apparently perfectly sound and good, but there are a number that are in very bad condition, and some which are practically entirely destroyed. By actual count, starting at the inshore end of the shore-arm and working out, out of 532 piles, taken as they came, 400 were in good or very fair condition, and 132, about 25%, were in poor or, in many cases, very bad condition. It was noticed that as a rule the piles which had deteriorated occurred in bunches, so that there might be three, four, or even eight or ten, one after another, all of which were in bad condition, and then there might be 50 or 60 which were all in good condition. No reason could be discovered for this, except that apparently the piles which had deteriorated in most cases show the creosoting strongly, but in a few cases no evidences could be detected of it, and probably some of the worst of the piles were never creosoted at all. As a rule the deterioration is apparently entirely due to rotting, and this rotting apparently begins at the top of the pile in the middle and works down, frequently leaving an outer shell which averages about an inch in thickness, which is still sound, although, of course, this shell is as a rule split from the top down. Apparently if the top of the pile had been thoroughly protected no deterioration would have taken place.

Very few instances of teredo attack were observed, and these were where the pile had evidently begun to deteriorate from rot before teredo began. As stated above, the piles on the channel-arm were in much better condition than those on the shore arm, very few, indeed, being in bad condition and none of them entirely useless. The waling pieces along the sides of the dike have for the most part entirely disappeared, but this is apparently due to the rusting off of the iron bolts which held them in place, and not to any fault of the timber. Wherever portions of the waling pieces remain, they were in very fair condition, except from wear due apparently to the action of the ice, waves, etc.; for the top portions were badly slivered, but the wood itself was remarkably free from rot and teredo attack. The wooden cross-ties were not in as good condition as the waling pieces, but most of them were still present, and as a rule not in very bad condition, considering the length of time they have been in place. That portion of the dike which is actually under water at low tide could not be examined, but, so far as could be judged, the lower portion of the piles is in better condition than the upper portion.

Generally speaking, the piles had stood remarkably well, for the conditions are severe, the piles being alternately covered at every high tide and exposed at every low tide.

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Entered at the New York Post-Office as Second-Class Matter.

Every engineer in any way interested in water distribution problems (and pretty much all branches of the profession have to meet these problems in one form or another) should give heed to the paper by Mr. Rudolph Hering in this issue on the economical layout of water-main systems. The problem discussed may seem a simple one; but it is one on which not a few engineers have been misled. The idea that a large main carried all around the borders of a city or a town ensures the best possible protection from fire to everything inside has an attractive sound and has misled many men whose mathematical ability and scientific training should have enabled them to discern the fallacy. Mr. Hering shows that for true economy the principle to follow is to lay your largest mains in the most direct course to the point of maximum probable demand. Just as soon as you depart from this principle you are adding to the length of your main and its cost without corresponding benefit.

The problem is not merely one of economy, for with a given amount of money to be spent, an ampler water supply and better fire protection can be secured by laying the main straight to the point where it is needed than by laying it in any circuitous course, no matter how specious an argument may be offered for the detour.

For a number of months we have reported regularly the monthly excavation on the Panama Canal, classifying this excavation according to the three divisions on the line with a subclassification under the method of removal, whether by hand, steam-shovel or dredge. As the record has progressed, however, it has become necessary for the administration to change its method of record-keeping so that now the classifications are quite different from those which we have published, and their further recording would only tend to confuse those engineers who are interested in the progress of construction and who have watched these monthly figures for an indication of this progress. In the future, then, we will not attempt to give this detailed excavation-account, but will content ourselves with a general record of work accomplished.

It is probable, though not certain, that the day of maximum excavation on the Isthmus has been passed. All along the line of the canal, levels have been reached where masonry construction can commence, so that the opportunities for record steam-shovel and dredge work are not so frequent as in the earlier stages. For that reason, records of excavation are not so indicative of progress as they have been nor are they very valuable as a gage to estimate the probable date of the canal opening. In future, then, the amount of work yet to be done on the Panama Canal would best be given out in percentages, figured out by the administration from the multifold reports sent in by various subordinates, in just such a manner as the stage of progress on our battleships is now reported.

For the benefit of those who still look toward figures for information, it may be well to give our own compilation of the excavation reports through June of the present year. Up to that time, there had been moved on the Isthmus by the American government 79,363,586 cu. yds. of material, 71,753,537 cu. yds. of which came from the canal prism proper, which, under the present estimate, leaves a total of about 95,000,000 cu. yds. yet to be excavated. In the first six months of 1909, the excavation totaled 19,382,599 cu. yds. for 151 working days, a daily average of 128,362 cu. yds. This average was increased by the remarkably good work done in the dry weather last spring and has not been reached by 10,000 cu. yds. in the last three months, when the rainy season has been on. The records of the last two months have dropped off from those of the correspondingly wet months of last year, but whether this is due to special conditions or to a general letting down in excavation remains to be seen.

Tests to determine the strength of rolled steel I-beams strike one as almost absurdly unnecessary. Such an everyday element of construction as the I-beam, it would seem, must be thoroughly well known as to strength and behavior; especially since designers have for years past employed the same working stress, 16,000 lbs. per sq. in., with no suspicion of a doubt as to its conservatism.

It is a fair matter for surprise, then, that a prominent college laboratory should have thought it worth while to make careful bending tests of I-beams, such as are reported by Prof. Marburg in his paper abstracted elsewhere in this issue. Equally surprising is it that the results are of more than routine interest, and that in fact they command attention through some unpleasant disappointments in their showings as to the strength of these beams.

We say unpleasant, because no doubt most of us have always had a silent conviction that an I-beam would develop practically the full strength of its material, i. e., would not fail until its extreme fibers were stressed approximately as high as the ultimate strength of the steel composing the beam. In this connection we have been inclined to think vaguely of something like 55,000 to 62,000 lbs. per sq. in., and to credit our beams, when stressed to a 16,000-lb. fiber-stress, with a safety-factor of 3½ to 4. When we see from Prof. Marburg's tests, however, that 15-in. I-beams averaged only 42,600 lbs. per sq. in. in ultimate strength, while 24-in. I-beams showed only 34,000 lbs. per sq. in., our tacit assumptions seem gravely over-optimistic, and our safety-factor drops to a figure between 2.0 and 2.7!

There is further reason for concern, even apprehension, in the low figures recorded by Prof. Marburg for the limit of perfectly elastic behavior in these bending tests. The results here are as low as 20,000 to 26,000 lbs. per sq. in. for the 15-in. and 24-in. beams, not to speak of the startlingly low average of 11,000 to 12,000 lbs. for the 30-in. beams. If we are to figure our loadings on the basis of elastic limit, with a fair safety-margin, where does this bring us as to working stresses?

On this last phase of the matter, it must be said, there is apt to be quite a difference of opinion, for, as we had occasion to discuss last week, the limit of proportional deformation is not accepted by all engineers as a gage of stresses or as a danger-point of the loading. But, conceding the full argument against attaching importance to the elastic limit, we still must admit that proper material should show strictly proportional deformation up to a much higher point; the material which gives the low results is not normal, or should not be considered normal. In fact, some of the tension tests on strips cut from these test I-beams exhibited very low elastic limit without showing an abnormal yield-point, and it is not easy to escape the conclusion that these particular strips represented poor material, as compared with other strips whose elastic limit was up much nearer the yield-point.

So important a subject as the strength of I-beams cannot, of course, be considered settled one way or the other by a very limited set of tests, made on beams coming from only one mill (presumably so, though Prof. Marburg does not say where the Standard I-beams were rolled). Another mill, with different rolls and different furnace-men, may produce beams of very different strength-characteristics, even if similar in chemical constitution. We should therefore like to see fuller experimenting, with beams from different mills, before extending Prof. Marburg's findings to rolled beams generally. In fact these tests make further tests seem quite necessary, if only to reassure.

But we almost forget the original purpose of Prof. Marburg's experiments, which was: to show whether wide-flange beams rolled on the Grey universal beam-mill are more or less efficient than the ordinary I-beams, per unit of section modulus. In this particular, indeed, the results are just what would have been expected, namely, that the section modulus is as fully utilized in the one kind as in the other. Not only is this result far from surprising, but we think it is rather unimportant. For, it does not argue generally against the standard sections or in favor of the wide-flange sections, inasmuch as the reduction of web-thickness, wherein the wide-flange beams get their advantage in section modulus, is not shown to be desirable.

Be this as it may, however, the comparison between standard and wide-flange beams which these tests furnish is clearly much less important than the showing of low strength in both kinds of beam. We therefore find here, as in many experimental researches, that the important result is a byproduct, while the result sought by the tests turns out to be quite secondary.

When laymen begin to teach health officers common sense there is hope for much-needed sanitary reforms. That such a lesson should be taught by a father who had just lost three children from diphtheria makes all the more remarkable the common sense of the layman and the apparent sanitary ignorance of the health officer. We give neither locality nor names, because we have not verified the story. We give the story without verification because even if the particular incident be not exactly true plenty of others involving the same sort of errors are. This is the story:

Three children in one family having died from diphtheria, alleged health officers are reported to have attributed the infection to a disused cement water main that had been converted into a sewer, and that extended across the premises on which the children died. The father of the children holds as the probable source of infection a child in a near-by house who died of diphtheria shortly before his children were taken ill; and he adds that this house was not quarantined during the illness and not disinfected until some time after the child died.

We record this incident because we feel it our duty to aid in bringing about a realization of the great need for more intelligent and efficient health officers; and also because almost any city engineer or superintendent of water-works or sewers is liable to be confronted with an assertion, if not from an health officer then from laymen, that diphtheria or scarlet fever or what not has been caused in some such ridiculous man-

ner. Such popular ignorance must be dispelled, and the people, including many unworthy guardians of public health, must be taught what to fear as possible vehicles of infection.

We have, from time to time taken occasion to call the attention of our readers to many remarkable engineering and scientific achievements. These great advances have been quietly announced for the most part, but none of them less so than a little invention, which has just come to our attention through a six-page circular, that defies the laws of the conservation of energy and the established theories of chemistry. For fear that some of our readers have missed seeing this circular, we reprint a few extracts:

In the celebrated "Blank" furnace we have incorporated the "Blankette" attachment. The "Blank" furnace with the "Blankette" attachment is now, without doubt, the most efficient—the most economical—and the best all-round hot-air furnace on the market. . . .

The Scientific Reason.—The "Blankette" attachment consists of an annular ring which fits tightly around the sides or walls of the fire-burning apparatus, with sectional metal plates lined with fire-resisting material fitted to said annular ring. The plates have holes through them in the nature of gas burners. . . .

The Attachment is heated to a degree which insures perfect combustion so that none of the gases can escape. Furthermore, the drafts of air coming continually up through the fire are deflected from the Attachment against the walls of the fire-pot and the fire itself, causing the fire-pot and ash-pit to become a live radiating part of the furnace—and further causing the fire to burn for hours at a white heat practically using this air as A fuel.

It is a well-known scientific fact that if hot oxygen or air is poured upon a mass of glowing carbon, the carbon is held at a white heat for hours at a time and the air itself is consumed and given off as heat. By these well-known principles,

The "Blankette"

First—Consumes all the gas (otherwise wasted).

Second—Keeps the heat in a fire-burning apparatus down where it belongs. . . .

Third—Burns air as a fuel.

It is certainly remarkable that this "well known scientific fact" has not been utilized before.

It will doubtless surprise many people outside of Pennsylvania to know that in 21 of the 67 counties of that state there are still in existence in this Twentieth Century toll roads 718 miles in extent, owned by 107 different companies. Less surprising, in view of the fact stated, is the recent appointment of a Toll Road Commission to investigate ways and means for abolishing these relics of the past.

Of course, Pennsylvania is a state of large area, and one in which there are thousands of miles of roads through sparsely settled districts. Nevertheless, it seems hard to account for the continued existence of toll gates and toll roads in such numbers. Nor are we sure that all these are located in the little-populated rural sections of Pennsylvania. Only a few years ago we had occasion to comment on the abolition or proposed abolition of toll roads located, if we remember rightly, within the city limits of Philadelphia. Such obstacles to the free movement of persons and goods should certainly be done away with as rapidly as possible in any part of the country. We understand that the movement for the abolition of toll roads in Pennsylvania has been prompted or accelerated by the work now under way or proposed for improvement of the main highways of the state.

To the record of data on the timeworn subject of small country highway-bridges we add the following news report on a bridge which was broken down by a steam threshing outfit:

It is a county bridge. It was remodeled only a couple of years ago and was considered strong enough to bear the weight of a traction engine. That such a mishap should have occurred is a matter of great surprise to the county commissioners, who were informed of what had happened early Saturday afternoon.

The commissioners evidently were grossly deceived at the time they "remodeled" this structure. We hazard the guess that the person who built the bridge assured the commissioners that it would safely bear any load that could come on it.

Nine Years of Water-Rate Litigation at Oakland, Cal.

The folly of making the water rates of a city subject to compulsory annual fixing by local municipal authorities was discussed in our issue of May 27, 1909, in connection with some comments relating to a court decision in an injunction case affecting the water rates of San Francisco. A fresh illustration of how annual rate-fixing fails to meet the objects intended is afforded by a decision of the California State Supreme Court relating to water rates established by the City Council of Oakland in 1900. The water-rate ordinance in question was passed early in the year 1900, and purported to fix the rates to be charged during the fiscal year beginning July 1, 1900. The rate ordinance was promptly taken into the courts, and, though the decision declaring the rates unreasonable was secured in one of the lower state courts in 1901, the case dragged on and final decision by the State Supreme Court was not reached until a few weeks ago. The judge in the lower court decided that the company was entitled to an income on a property valuation of $7,000,000, which was substantially what the engineers brought forward by the company claimed the works were worth. The engineers for the city valued the works at about $3,000,000. The Supreme Court decides that the higher valuation was not warranted by the evidence. Apparently, the case is to go back to the lower court for a new trial, thus leaving the rates for the fiscal year 1900-01 still unsettled.

The water rates legally chargeable by the company supplying San Francisco for the past half-dozen years or so, with the exception of one year only, are all in the courts and have been the subject of an immense amount of testimony and proportionately voluminous legal briefs and arguments. As an illustration of the growing complexity and long delays incident to the San Francisco litigation it may be noted that in a recent argument on final hearing on the disputed rates of the earlier years, quotations were made from a decision rendered this year in a suit for preliminary injunction on the rates for 1908-09.

We have referred heretofore in general terms to the cause for this seemingly endless litigation over the water rates of San Francisco and Oakland. It seems worth while to put on record, for the convenience of our readers, the particular clause of the State Constitution of California which has given rise to so much controversy. This (Article XIV., Section 1) is as follows:

The use of all water now appropriated, or that may hereafter be appropriated for sale, rental, or distribution, is hereby declared to be a public use, and subject to the regulation and control of the state, in the manner to be prescribed by law; provided, that the rates or compensation to be collected by any person, company or corporation in this state for the use of water supplied to any city and county, or city or town, or the inhabitants thereof, shall be fixed, annually, by the board of supervisors, or city and county, or city or town council, or other governing body of such city and county, or city or town, by ordinance or otherwise, in the manner that other ordinances or legislative acts or resolutions are passed by such body, and shall continue in force for one year and no longer. Such ordinances or resolutions shall be passed in the month of February of each year, and take effect on the first day of July thereafter. Any board or body failing to pass the necessary ordinances or resolutions fixing water rates, where necessary, within such time, shall be subject to peremptory process to compel action at the suit of any party interested, and shall be liable to such processes and penalties as the Legislature may prescribe.

Any person, company or corporation collecting water rates in any city and county, or city or town in this state, otherwise than as so established, shall forfeit the franchises and water-works of such person, company or corporation to the city and county, or city or town, where the same are collected, for the public use.

A notable feature of this constitutional provision is the declaration that if other rates than those fixed by the municipal authorities are collected, the franchise and property of the company shall be forfeited. In view of this provision, the courts recognize that they must steer clear of any attempt at actual rate fixing. The principle involved, we believe, is well-recognized law in connection with most or all court adjudications of rates to be collected by public-service corporations.

The history of the litigation at San Francisco and Oakland, as well, doubtless, as much similar history in other suits, indicates clearly how desirable it would be, if law and justice would permit, to make the rates fixed by public rate-fixing bodies superior to court review. This seems to be impossible under most if not all state constitutions, and also under the constitution of the United States. In some European countries, we believe, court reviews of this character are not permitted.

As matters now stand, a large part of the time of many courts is taken up with rate-litigation cases, thus seriously delaying other lawsuits which may be of equal or greater importance. While the courts repeatedly disclaim any acts or opinions which could be interpreted as attempts at actual rate-fixing, the facts often are that they really do go much further in the way of fixing rates, or at least of gathering and sifting testimony on which rates should be based, than do the regularly constituted rate-fixing bodies. Such voluminous testimony as has been piled up in the San Francisco cases, for instance, really ought to be submitted to the rate-fixing body instead of the court, if indeed it were permitted at all in either case.

One of the principal objects of and justifications for state public-service commissions is to relieve municipalities and courts alike of rate-fixing problems and difficulties, by vesting them in bodies chosen for that purpose. While the courts are by no means wholly relieved of rate controversies by these commissions much relief is doubtless thus gained, and we believe it will increase as time goes on. It would seem both possible and reasonable to so correlate the public-service commissions and the state courts that the latter would become virtually courts of appeal instead of trial courts for rate cases. With the United States Courts the problem of statutory relief would, of course, be more difficult, but much can be done by the U. S. Courts themselves in refusing to meddle in rate cases wherever that is possible.

As we pointed out in our issue of May 27, 1909, already mentioned, it is ill-advised, to say the least, to have the rates of a public-service corporation established annually. Regardless of the frequency of adjustment, such rates should be fixed by a state rather than by a local board. Furthermore, and of great importance, the principle should be established as rapidly as possible in all the states of the Union, that the accounts of public-service corporations should be so kept as to make wholly unnecessary some 95% or more of the testimony regarding the value of works, revenue, expenses and net income that is now taken whenever rate litigation arises. This is the only just way of safeguarding the interests of both investors in public-service-corporation securities and patrons of these companies. Aside from the mere matter of justice, such a reform is needed in order to save an enormous amount of time and energy that is now put into these rate cases by engineers, lawyers, and courts. Even though there was a rate-adjudicating branch of the court system of the several states, it would still be desirable, and eventually would prove to be almost absolutely necessary, to reform public-service-accounting systems along the line suggested.

LETTERS TO THE EDITOR.

Conflicting Statements as to the Value of Different Bitumens for Road Making.

Sir: The general confusion of ideas on the characteristics of different bitumens and their value as road-building materials, and the absence of any scientific standard of ascertaining the value of such bitumens, are illustrated by three papers lately written by Mr. Clifford Richardson, two of which were read by title at the meeting of the American Society for Testing Materials [June 28-July 3], while the third was read at the International Good Roads Congress at Seattle, Wash., about the same time.

In Mr. Richardson's paper entitled "Bituminous Materials In and On Road Surfaces, And Means of Deter-

mining their Character," there appears the following paragraph:

In general, it may be said that those materials which contain the largest amount of solid native bitumens, compatible with their use with cold aggregates, are much more desirable than any others, at least as far as the construction of macadam highways is concerned, for the reason that surfaces constructed with them bear a much closer relation to sheet asphalt pavements in their capacity to resist the conditions to which they are exposed than materials originating in petroleum oils alone, even if the latter are of an asphaltic nature.

This paragraph states definitely that in Mr. Richardson's opinion solid native bitumens (that is, according to Mr. Richardson's statements for a number of years, bitumens which are found in natural deposits in a solid state) are much more desirable than any others, particularly than materials originating in petroleum oils, even if the latter are of an asphaltic nature.

In Mr. Clifford Richardson's paper, "Methods for the Examination of Bituminous Materials for Road Construction as Practiced in the New York Testing Laboratory," he states that petroleum oils have very feeble (if any) cementing value, not stating by the way any definition of "cementing value."

These two paragraphs are very definite. There is no possible chance of misunderstanding the position taken by Mr. Richardson in these papers, as the statements are absolute assertions without any qualifications and are entirely general. These statements assert that petroleum oils or materials made from petroleum oils are not as valuable materials as solid native bitumens.

In Mr. Clifford Richardson's paper read before the International Good Roads Congress at Seattle, entitled "Asphalt Macadam Roadways," there is the following paragraph:

On the Pacific Slope, the opportunity for the construction of roadways of the highest type, which has been described, is facilitated by the fact that vast quantities of residual pitch and flux, most of it of suitable quality, are available as a cementing material or binder, so that all that is necessary is a certain amount of skill and experience in handling it, to attain the best results. In fact there is no part of the world which is so favorably situated for solving the road problem as the state of Washington, where stone of the highest grade is available for the mineral aggregate, and a cheap and abundant supply of cementing material from the neighboring state of California. The state is to be congratulated on the opportunities which it has in these directions, upon the energy with which the road problem is being attacked, and upon the prospects of success which lie before it.

This paragraph relates to California petroleums.

California petroleums are not solid native bitumens. California petroleums are petroleum oils.

It is astonishing that it should be possible for a man of Mr. Clifford Richardson's prominence to make (in papers which were published at about the same time and deal with the same subject) three statements equally assertive, equally pronounced and entirely contradictory.

It is no wonder that the average engineer should be confused and skeptical regarding the statements made by people engaged in the production of bitumens for different purposes, when it is possible for one of the few writers on this subject, who has confessedly made this particular subject his special study for many years, to so flatly contradict himself in papers published at the same time.

Such an absurdity naturally lays open to criticism the practice, either in construction or tests, which may come from such a source. It would seem to be the proper thing at this time for supposed scientific papers on such an involved subject to avoid general statements without attaching reasons and evidence which can be considered by an engineer of intelligence as adequate.

The paving industry and the corresponding industry of road-making has been always burdened with too many positive statements made without any scientific reason or any deductions which could be considered by any stretch of the imagination as offering proper evidence for them.

If the proposition is ever to be brought to the scientific exactness which is the chief feature of modern engineering in other branches, it would seem necessary:

First, to avoid making sweeping general statements, which are not founded on experience or experiment, which are generally contradicted and have never been supported by evidence; and

Second, to pursue an investigation with the intention and hope not of confusing the issues but of arriving at such knowledge as will tend to improve conditions and increase the possibilities of good construction adapted to the present needs.

Harry Tipper.

17 Battery Pl., New York City, July 7, 1909.

[Proof of the above letter was submitted to Mr. Richardson. Reply was delayed by the latter's absence. Mr. Richardson's answer follows. —Ed.]

Sir: I am indebted to you for the privilege of reading a copy of letter from Mr. Harry Tipper to you which criticizes what he denotes as certain conflicting statements as to the value of different bitumens for road making in certain papers presented by me at the recent meeting of the American Society for Testing Materials and at the First American Congress of Road Builders at Seattle.

Mr. Tipper, and perhaps others, as it does not seem to have made sufficiently plain, does not appreciate that the statements in the paper entitled "Bituminous Materials for Use In and On Road Surfaces, and Means of Determining Their Character" apply to the oils of the Eastern States while those in the paper "Asphalt Macadam Roadways" apply to the highly asphaltic California petroleums, which are entirely different materials and of different origin and character.

The only way in which I would modify any of the statement in my papers at the present time would be that in the light of information recently obtained by me personally on the Pacific Coast I would say that some only, and not much, of the residual pitch which is now available there is suitable for use in the construction of macadam roads.

Very truly yours,

Clifford Richardson.

30 Church St., New York City, Aug. 9, 1909.

A Method of Repairing Steel Tapes.

Sir: I have seen so many unsatisfactory makeshifts at mending tapes and so few who know about the simple but effective method outlined below, that I think it worth publishing.

Dissolve zinc in muriatic acid to saturation. Bend a piece of tin, about ½-in. wide and long enough to reach around the tape, around the broken place firmly, being sure the steel and tin are clean. Put a few drops of the solution and a small piece of solder on the joint; hold over a burning candle or any small blaze until the solder melts. When properly done this never fails to give a satisfactory repair.

For a field repair outfit buy five cents worth of muriatic acid and in a tea cup or glass, out doors to escape the fumes, dissolve zinc in the acid. Then for convenience carry in the transit or level box a small vial of the solution, the solder, a small pair of steel pincers, and a few old tin can seals. With these conveniences one can keep his tapes in good repair.

Very truly,

W. H. Fuller.

Hastings, Neb., July 30, 1909.

Fine Grinding in Cement; How Is It Measured and What Is Its Value.

Sir: In your issue of July 22, 1909, p. 105, after a brief review of a paper entitled "A Suggestion as to Commercial Use to be Made of Cement Testing," read before the American Society for Testing Materials by Mr. Richard K. Meade, you comment as follows: "It should also be stated that the remarkable advantage of fine grinding claimed by Mr. Meade is not accepted by all cement experts."

I regret that Mr. Meade did not go into this part of his subject a little more fully, for I think the paper as it stands conveys some false impressions. There is nothing mysterious about the increase of strength due to fine grinding and I think most of the uncertainty and difference of opinion on this matter is due solely to our inaccurate use of terms. A pile of unground clinker is not cement and it does not become cement until it is ground to such a degree of fineness that it is capable of uniting with water to form a hydrate. If this is a correct definition then the material which does not pass through a 200-mesh sieve is not cement at all, but merely small particles of clinker, for it has no cementing properties remaining unaffected by water either cold or hot for any length of time.

It is a fact less generally recognized that a large percentage of the material that passes through the 200-mesh sieve is still not fine enough to be acted on by water and therefore not really cement.

If engineers would realize that a sack of ordinary cement contains only about half its weight of actual cement, the remainder being the equivalent of fine sand, they would be more ready to accept the idea that if the manufacturer can reduce the percentage of inert material in a sack of cement the engineer may replace this with an equal amount of sand without reducing the strength of the concrete.

Mr. Meade's statement that an increase of 1% in fineness as measured by the 200-mesh sieve would result in an increase of 2% or more in strength is only true in some cases, for the strength is not proportional to the percentage that passes the 200-mesh sieve, but to the percentage of powder fine enough to be acted upon by water. I do not know what Mr. Meade's experiments have been along this line, but probably his fine ground cement was the product of Fuller-Lehigh mills and his coarser cement was ground in tube mills. Comparisons of a great many sieve tests of different brands of cement show that the Fuller mills increase the percentage that will pass through the 200-mesh sieve much more than the increase in the percentage passing a 100-mesh sieve. If a still smaller size is separated by some elutriation process the difference is greater than shown by the 200-mesh sieve. If, however, the comparison is between two samples ground in the same type of mill the increase in the percentage of fine powder may not be any greater, and under abnormal conditions may even be less, than the increase in the percentage passing the 200-mesh sieve.

Now that the improvements in grinding machinery are making finer grades of cement commercially possible, I think that cement experts should give more study to this matter along the following lines:

(1) To determine the maximum size of particles that are chemically active.

(2) To devise a practicable method of testing the fineness of cement to determine the percentage of particles that are below this size.

(3) To demonstrate the relation between the percentage of fine powder in the cement and the crushing strength of concrete made from it.

(4) To discover the best method of proportioning concrete, based on the fineness of the cement, so as to secure the greatest benefit from the finer grinding, either in strength or economy.

Kenneth Hartley.

1500 Grand Ave., Kansas City, Mo., July 31, 1909.

[Our comment quoted above was made with precisely the same idea in mind as is expressed by Mr. Hartley; viz., that although set cement owes its strength to only the finest of the particles in the unset material, that strength is not directly proportional to the fineness *as measured by the usual commercial method of mesh sieves.*—Ed.]

The Recent Broadside on the Proposed Lease of the Philadelphia Water-Works to the Municipal Improvement Co.

Sir: As you are probably aware, the water situation in Philadelphia is again becoming interesting.

You will probably remember that, about eleven years ago, one N. G. Green (then Nelson G. now N. Goodwin), of Providence, R. I., recognizing the straits into which the Philadelphia water-supply had been brought by "political" mismanagement, came to the rescue with a Schuylkill Valley Water Co. proposition, contemplating the impounding and filtration of the Schuylkill water at a point some thirty or forty miles above the city, and the delivery of the filtered water, by gravity conduits, to the existing pumping stations.

At that time I was chief of the bureau of water here, and Mr. Green told me that the passage of the company's ordinance was assured, and asked me to compare notes with his engineer, Mr. L. K. Davis, and inform myself as to the proposed arrangements.

In conversation with Mr. Davis, I ventured to express the view that the city was not in need of the company's benefactions, inasmuch as it was already pumping twice as much water as it needed, and that all the city need do was to restrict the waste. To this Mr. Davis replied: "You know very well that the administration, which puts meters on this town, cuts its own head off." In other words, Philadelphia was just the town for a water snake.

In a report to the director of the department of public works, I discussed the company's proposition, setting forth its needlessness and certain technical defects, notably a broad and shallow impounding basin, which, at low water, would expose large areas of nearly level bottom. But what threw the company's fat in the fire was a statement, by a member of councils, upon the floor of that chamber, that he had been offered a substantial bribe for his vote.

Now Mr. N. G. (N. Goodwin) Green comes forward with a broadside, addressed to the public over the signature of "Municipal Improvement Company" (Mr. Green modestly withholding his own name), setting forth the city's present financial plight and the alleged insufficiency of the present supply, and offering to furnish the funds necessary to render the supply sufficient.

The broadside states that:

The most important and most glaring loss that confronts the city to-day is that occasioned by the operation of its water system. Not within the memory of any inhabitant has there ever been a time when you have had sufficient pure water for your household use.

The filtration plant, filtration bureau, water-pipe system—in short, the entire water system of Philadelphia—is draining this city's treasury to the extent of $700,000 each year.

The Municipal Improvement Company then proposes:

To assume the operation of the entire water system.

To bear all of its expenses.

To not increase the cost of water to the consumers.

To increase the supply of pure filtered water to the full capacity as needed by Philadelphia.

To complete the entire filtration system.

To re-pipe the entire city with clean, serviceable, high pressure mains.

To wipe out the annual deficit by operation of these works of $700,000 a year.

To pay to the city of Philadelphia $12,000,000 in cash in three annual payments.

To pay to the city a graduated and ever-increasing amount each year.

Which, during the period of the lease will, with improvements amount to $100,000,000.

To furnish to the city for municipal use its water free.

To return to the city a water system worth millions of dollars, free and without cost.

Which will provide immediate money for the payment of all outstanding accounts.

Which will stop all bond issues for current revenues.

Which will enable the city to appropriate to its various departments and bureaus at once sufficient money to operate them properly.

And to render it possible for the present administration to give to Philadelphia:

85-ct. gas.

The resumption of the construction of the magnificent parkway.

The completion of the great Torresdale Boulevard.

The broadside states that the company has submitted to the mayor a proposed lease, providing as follows:

(1) For the lease and operation of the entire water-works system.

(2) For the operation, maintenance, enlargement, extension and betterment of the same.

(3) For the payment of $12,000,000 in three equal annual installments.

(4) For the payment of an ever-increasing yearly revenue, based on the consumption of water, which will amount to a total of about $50,000,000.

COST OF STEAM PUMPAGE (PUMP-HOUSE EXPENSES) AT PHILADELPHIA, 1894-1907.
(From Annual Reports of the Bureau of Water.)

	Billions of gals. 100 ft.	Fuel cost for year.	Fuel cost per mil. gals. 100 ft.	Pay of employees for year.	Pay of employees per mil. gals. 100 ft.	Total for year.	Total per mil. gals. 100 ft.
1894.....	121.2	$226,700	$1.87	$118,500	$0.98	$422,252	$3.48
1895.....	132.0	274,311	2.08	131,612	1.00	487,765	3.69
1896.....	161.8	322,226	2.00	148,856	0.92	556,304	3.44
1897.....	187.4	349,320	1.86	158,154	0.84	591,480	3.16
1898.....	210.8	373,199	1.77	177,630	0.84	625,159	2.97
1899.....	231.8	410,789	1.77	185,199	0.80	672,526	2.90
1900.....	218.1	460,677	2.11	231,617	1.06	810,078	3.71
1901.....	227.7	465,691	2.04	297,907	1.31	871,886	4.14
1902.....	239.7	611,519	2.55	390,700	1.63	1,152,229	4.80
1903.....	248.8	744,563	2.99	381,715	1.54	1,292,456	5.26
1904.....	251.2	733,697	2.93	375,941	1.49	1,284,004	5.11
1905.....	261.3	665,742	2.55	383,747	1.47	1,204,628	4.61
1906.....	257.3	647,808	2.52	404,758	1.57	1,302,240	5.06
1907.....	242.3	625,403	2.57	442,089	1.82	1,376,123	5.68

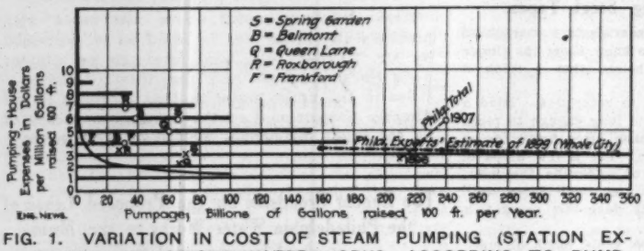

S = Spring Garden
B = Belmont
Q = Queen Lane
R = Roxborough
F = Frankford
Phila. Total 1907
Phila. Experts' Estimate of 1899 (Whole City)
Pumping = House Expenses in Dollars per Million Gallons raised 100 ft.
Pumpage; Billions of Gallons raised 100 ft. per Year.
ENG. NEWS.

FIG. 1. VARIATION IN COST OF STEAM PUMPING (STATION EXPENSES) AT VARIOUS WATER-WORKS, ACCORDING TO PUMPAGE, COMPARED WITH COSTS AT PHILADELPHIA STATIONS.

(The curve is an approximate mean, based on figures given in Jour. N. E. W. W. Assoc., September, 1896; Munic. Jour. and Engr., May 6, 1908, and annual reports of the water-works of Harrisburg and Reading, Pa., Fall River and New Bedford, Mass., and Absecon Station, Atlantic City, N. J.)

(5) To expend during the term of this lease on improvements probably $50,000,000.

(6) To, upon returning the entire system to the city free of all cost, have paid it about $82,000,000 in cash and to have increased its value about $50,000,000, or a total direct benefit to the city of $112,000,000.

(7) To return to the city all land and property not required by us for the operation of our lease.

(8) To bear all expense of maintenance, improvements, repairs and operation.

(9) To enlarge, extend, repair, relay mains, pipes and services throughout the entire city.

(10) To make all repairs to streets and highways in accordance with the rules and regulations of the proper departments.

(11) To pay the city for all supplies on hand.

(12) To immediately upon passage of the lease and execution of the agreement, and before taking possession of the water-works system, execute and deliver to the city our surety bond in the sum of one million dollars for the faithful operation of the water-works.

(13) To maintain a standard of filtered water to be delivered by the city's engineers.

(14) To sell all water on the basis of the present city rates.

(15) At no time to install water meters now prohibited by law.

(16) To be subject to the mayor, city councils and the inspector of water.

(17) To supply free water for all public buildings, public hospitals, fire and police stations, fire hydrants and for the flushing of streets.

(18) To extend distributing mains and pipes upon the request of consumers.

(19) To neither have control over nor responsibility for the high pressure fire service.

(20) To insure against loss by fire all buildings, fixtures and machinery used by the company.

(21) To pay to the city apart from the graduated increasing rentals, $10,000 per year for maintaining the office of Inspector of Water.

You will note particularly the fifteenth proposition in this last series: "At no time to install water meters now prohibited by law," which shows that Colonel Green, who hails from the metered city of Providence, is aware of the misconception, by our people, as to the office of the water meter, and is willing to take advantage of this ignorance, without which, of course, there would be not even an apparent excuse for his proposition. Fancy Colonel Green shouting "no meters" to the public in Providence!

To the layman, the "politics" of the situation suggests some interesting questions. Mr. Green is sufficiently man of the world to know that, during recent years, it would have been idle to bring before the councils or the people of Philadelphia any such proposition without first having it stamped with approval by the contractors who run the city. Now it happens that, with one accord, these gentlemen and their fellow-politicians vociferously announce their opposition to and contempt for this latest scheme of Mr. Green. Why then does he have the hardihood to bring it before us? Is the opposition of the leaders merely a bluff, are they really "in it," or does Mr. Green suspect that the grip of these gentlemen upon the city has somewhat relaxed of late, so that he dare proceed without their "O. K."?

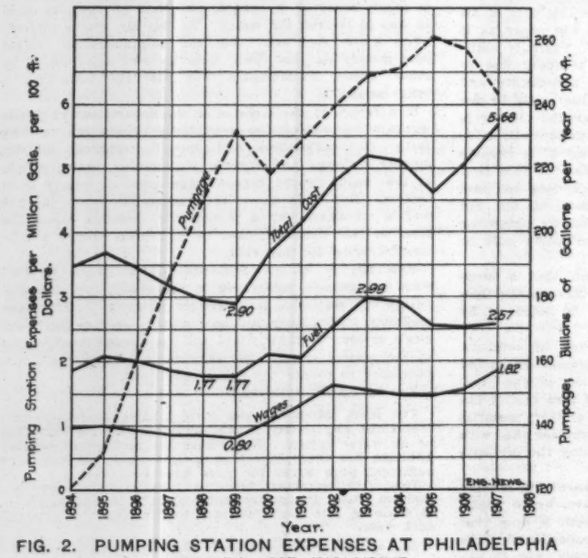


FIG. 2. PUMPING STATION EXPENSES AT PHILADELPHIA 1894 TO 1907, INCLUSIVE.

You may remember that we have just passed through a trolley strike which was ostensibly settled by a wave of the wand of the chief contractor-boss. Whether or not it was this fulsome exhibition of power at a critical moment, or whether it was general disgust, on the part of the people, with the traction company and its "political" confederates, the recent primary election showed so startling a revolt that the politicians were forced to sit up and take notice. Since then, they have been displaying an almost startling disposition to goodness; and one of the most curious features is that, since Mr. N. G. Green's proposition was sprung upon us, the city fathers, of their own motion, have sent their finance and water committees upon a tour of inspection of the water-works, to see whether perhaps they had been working the community a little harder than the traffic would bear.

Mr. Green, in his broadside, makes no distinct charges of padded payrolls or other extravagance; but, so sensitive has the organization conscience become, since the late primary election, that some such action was thought advisable.

The grim humor of setting a councilman to catch a councilman must be manifest to all but the councilmen themselves. Could anything be more amusingly pathetic than this tour of city fathers among the pumping stations and filter plants, each recognizing, at the various points, his numerous "friends," and confronting the question, which of these friends must be sacrificed, in order, if possible, to make some kind of showing before the November election.

The tacit councilmanic admission of extravagance throws a side light upon a feature which came to my notice recently.

I had occasion to study the relation between the size of a pumping plant and the cost of operation per unit of work done; and, for this purpose, I plotted a large number of data, obtaining the curve shown in Fig. 1, from which it appears (1) that the cost, per unit of work done, is, as might be expected, very high in very small plants; (2) that it drops very rapidly as the size of these small plants increases, and (3) that, at a very moderate size of plant, the curve turns abruptly and becomes nearly horizontal, further increase in size of plant producing relatively little diminution in cost of operation.

Now, Philadelphia having probably the largest municipal pumping plant in the world, I was naturally curious to see how it stood in relation to this curve. To my surprise, I found that the cost, in 1898 (when I was in nominal charge of the Bureau of Water) was about double what it should have been according to this study; but I was still more surprised when I came to plot the cost for 1907, the date of the latest annual report, and found that the cost then was nearly double that of 1898, or about four times what it should have been; notwithstanding that, in the meantime, the pumpage had materially increased (a change which should have slightly diminished the cost per unit of work), and notwithstanding that the proportion of antiquated and low-duty pumps in the system had very greatly diminished.

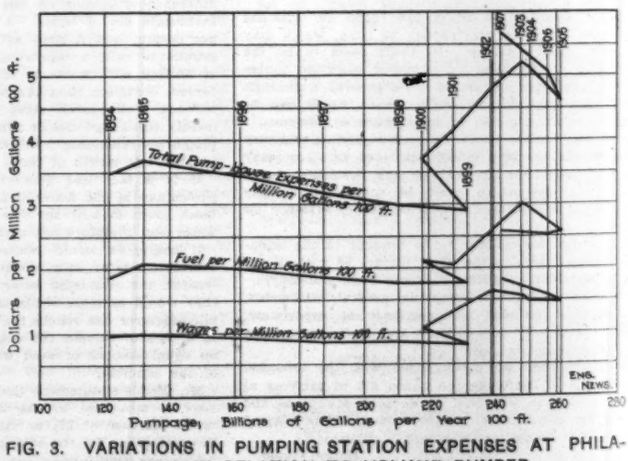

Total Pump-House Expenses per Million Gallons 100 ft.
Fuel per Million Gallons 100 ft.
Wages per Million Gallons 100 ft.
Dollars per Million Gallons 100 ft.
Pumpage; Billions of Gallons per Year 100 ft.
ENG. NEWS.

FIG. 3. VARIATIONS IN PUMPING STATION EXPENSES AT PHILADELPHIA IN RELATION TO VOLUME PUMPED.

Figs. 2 and 3 show the variations in cost in Philadelphia between 1894 and 1907. The figures, upon which Figs. 1 and 2 were based, were taken from the annual

reports of the Bureau of Water. They are given in the accompanying table.

I need hardly say that the foregoing involves no reflection upon Mr. Fred C. Dunlap, Chief of the Bureau of Water. When I held the same position the chief was little more than a head clerk, acting nominally as adviser to the director of the department of public works, who, however, was appointed by the mayor, who, in turn, owed his position to the good graces of the politicians.

I take it for granted that the same condition prevails at the present time, and that Chief Dunlap is as little responsible for the fact that his cost of pumping is four times what it ought to be, as I was responsible for the fact that mine was twice what it ought to be.

Yours truly,

John C. Trautwine, Jr.

257 S. Fourth St., Philadelphia, Pa., July 19, 1909.

[In our issue of May 13, 1909, we referred to this Philadelphia water lease proposition as something which would undoubtedly "come to naught." We had not then seen the broadside mentioned by Mr. Trautwine. That pamphlet is indeed a remarkable piece of promotion literature, as may be inferred from the small portions of it quoted above. A large part of the broadside is devoted to a mass of figures, said to be taken from Philadelphia municipal reports, designed to show that the Philadelphia water-works are being operated at a loss, and that the funds which would be made available to the city by the proposed lease are badly needed for other municipal purposes. How the company is to take up such a losing proposition as it claims the water-works to be, put vast sums into the improvement of the works, pay the city large sums in cash, turn the improved works back to the city without charging the latter for millions on millions of improvements, and still pay dividends to its stockholders the broadside does not explain. There seems to be only one explanation, assuming the lease proposition to be made in good faith, and that is that in the opinion of these promoters the Philadelphia water-works are now being grossly mismanaged. The writer of the broadside is of course too shrewd to say this directly, but indirectly the broadside bristles with financial statistics and text which seem to indict not only the management of the water-works but the financial and general administration of the city as well.

How reliable the figures given in the broadside are we cannot say. There can be no question, though, but what the whole municipal administration of Philadelphia needs improving. Why should the Municipal Improvement Co. stop with the water-works? Why not lease and administer the whole city of Philadelphia?

Without at all favoring the proposed lease, or expressing the belief that it is likely to be made, we must say that the figures in the broadside seem to demand attention on the part of the citizens and taxpayers of Philadelphia. The latter portion of Mr. Trautwine's letter indicates that something is very wrong with the operations of the pumping stations, and has been for years. If it costs four times as much to pump water at Philadelphia as elsewhere, why should not one infer that the operation of other portions of the works was quite as extravagant, and that the water-works revenues suffer grossly from mismanagement in the collections of rents, and that the water-works accounts as a whole are not so kept as to show whether the works are operated at a profit or a loss, or at least so as to show what the loss is?

If the broadside is a libel on the water-works and on the city government of Philadelphia generally, why do not the responsible officials say so? Or do they consider the antecedents of the Municipal Improvement Co. such that its broadside demands no answer?—Ed.]

A TELEPHONE SYSTEM FOR PEKIN, CHINA, it is reported, has recently been contracted for by the Chinese Government with the Western Electric Co., of Chicago. The plant contracted for will have a capacity of 10,000 lines and will be of the latest design. Only 2,500 lines will be installed at first and the system will be operated by the government. At present there are estimated to be 2,000 antiquated telephone instruments in the whole Chinese kingdom.

Mule-Back Transportation of Sectionalized Machinery.*

By F. C. ROBERTS and WALTER W. BRADLEY.

The subject of mule-back transportation is an old one. Because of its many supposed limitations and "impossibilities" this form of transport has usually been considered applicable only to small plants. A notable example of the sectionalization of large-capacity power, mining and reduction-units, and the transportation of this plant to districts accessible only by mule-back has been recently afforded in the case of the Ventanas Mining & Exploration Co. in Durango, Mexico, with which the writers were connected as consulting engineer and assistant manager, respectively. The success attained

Fig. 1. Mule-Back Transportation of Agitator Shaft for Ventanas Mining & Exploration Co. in Durango, Mexico.
(Length of shaft, 13 ft. 6 ins.; diameter, 3 15-16 ins.; weight, 580 lbs.)

makes pertinent the query, how many manufacturers of mining machinery appreciate the potentialities of business expansion by designing large units sectionalized for mule-back transport?

One deterrent has been the time honored load-limit of 350 lbs. The fact is that with proper organization of crews, good food and the exercise of judgment in assigning loads best suited to certain animals it is possible to handle over heavy mountain trails, loads of 475 to 500 lbs. and when necessary as much as 680 lbs. in one piece. In the accompanying illustration (Fig. 1) is shown a mule carrying a section of $3^{13}/_{16}$-in. steel shafting, weighing 580 lbs.

The town of Ventanas or Villa Corona, as it is officially known, is situated about midway between the city of Durango and the Pacific port of Mazatlán. It is about 20 miles south of San Dimas, Durango, but it takes two days to make this short journey. It is at an altitude of 1,700 ft. above sea-level. Access to the camp is circuitous and difficult. Leaving Ventanas, there is but one route of descent, that along the river-bottom in a westerly direction. The town is accessible by mule-back transportation from Durango practically throughout the whole year, and from Mazatlán for about seven months, either journey requiring about ten days for pack (*carga*) mules. The profile shown in Fig. 2 will help to convey an idea of the altitudes and conditions met on the trail from Durango to Ventanas. "As the crow flies," it is approximately 65 miles, but by the route followed it is 105. As already stated a *carga* mule requires ten days to make the journey, but with a saddle animal a man may make it in three or four days.

The veins in the district had been worked in a small way many years ago, first by Spaniards, afterward by Mexicans and later by four Americans who wandered there nearly 40 years ago. Since they were dependent upon high-grade ore, their operations were necessarily restricted and during the last ten years or so, they installed almost every type of small-unit plant that had been placed on the market and attempted nearly all the metallurgical processes described in the text-books, in an endeavor to treat the lower-grade material. While their efforts were not altogether successful, they deserve a great deal of credit for persistence and pluck in facing unfamiliar conditions of living.

The Ventanas M. & E. Co. had practically agreed to undertake the purchase of the group of veins in the district, and to erect a reduction-plant and hydro-electric power-plant before it was by any means certain that manufacturers would undertake to sectionalize many of the important machines. The capacity of plant fixed upon was about 200 tons (dry weight) per day, the experimental and metallurgical tests indicating that both in initial cost and in economic treatment of the ore, an "all-slime" plant would be most effective. The fineness of the product was to be maintained so that 90% would pass a 200-mesh screen.

The plant was designed and erected by F. C. Roberts, consulting engineer. The selection of the machinery was made with a view to careful sizing and to "step-crushing," and the capacity of the units was so fixed that the aerial trams, rock-breakers and sorting-belt were required to be in operation only ten hours per day. The plant was projected with the idea that the ore should be made to suit the individual units, that is to say, it was contended that the most economic results would follow if the product assigned to each unit was maintained at such a degree of fineness as would best harmonize with the design of that unit, providing, of course, that the selection of units was a wise one. All was planned with the intent that tube-mills should be used as the final crushing-device.

The ore is delivered to a central crusher-station by two automatic aerial trams, furnished by the A. Leschen & Sons Rope Co., of St. Louis, Missouri, and discharged to grizzlies set with 2-in. spacing, the undersize falling directly into bins below, and the coarse to sorting floors convenient to the jaw-crushers. The coarse-crushing equipment, Blake crushers, belt-conveyor, trommels, and rolls, came from the shops of the Allis-Chalmers Co. The sectionalization of these was made up of standard sizes furnished by that firm.

The use of rolls was an experiment in this case prompted by the knowledge that skilled labor for stamp-mill practice was considered to be hard to get, and the fact that the pioneers of the camp had used rolls for some years which ran largely without attention, and much better with poor administration than any stamp-mill either of the writers had ever seen. Besides this, Mr. Roberts' preliminary experiments indicated that for producing a ⅛-in. product, the rolls gave a lower percentage of slime, and the capacity per HP. was greater than perhaps could have been obtained with stamps. From the de-watering cones below the finishing rolls, the product is equally divided among three Abbe Engineering Co.'s tire-type tube-mills, a fourth mill being used for the oversize. This oversize is elevated from the four separating cones below the tubes, by a 22-ft. tailing-wheel, the overflow going direct to the treatment tanks. The agitation plant consists of 14 steel tanks, 30 ft. in diameter by 10 ft. deep, equipped for mechanical agitation. After a charge is treated, it is transferred to a collecting vat and thence to a vacuum-filter, and then passes through a sand-filter to extractor boxes, filter-presses and sumps from which it is pumped back for service. Ground was broken on Jan. 23, 1907, and the tube-mills were first turned over for service on July 19, 1908, the entire plant beginning operation on Aug. 10, 1908.

All machines in the plant are operated by separate 8-40-900-60-2080 General Electric induction motors. There are 14 of these 40-HP. motors and three of 30-HP. Power is furnished from hydro-electric plant, situated five miles up the river from Ventanas, consisting

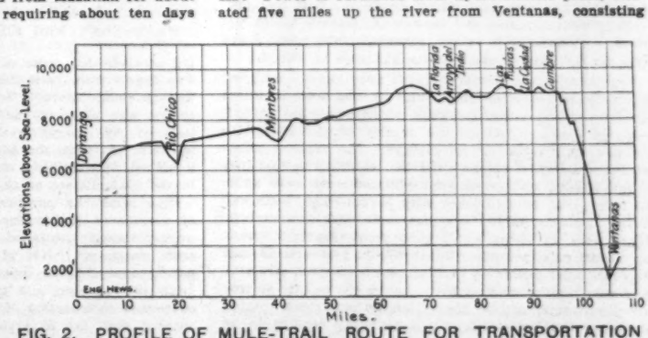


FIG. 2. PROFILE OF MULE-TRAIL ROUTE FOR TRANSPORTATION OF SECTIONALIZED MINING MACHINERY.

of two impulse water-wheels, furnished by the Pelton Water Wheel Co., of San Francisco, controlling three 12-200-600-60-6600 General Electric alternators. The hydro-electric installation was particularly interesting work; not only because of the theoretical accuracy of the machines supplied by the manufacturers, shown later in the practical efficiency of both water-wheels and generators, but also in the engineering difficulties attendant on the selection of the ditch-route.

As regards sectionalizing, the aerial tramways, although not involving intricate engineering problems, required the exercise of a great deal of care in order to keep within proper limits of weight and to retain the strength where it was required. In transporting the cables, the coils were made up and tied with wire in the factory before shipping, each mule's load being divided into two parts, with about 12 ft. of cable between

*Reprinted from the "Mining and Scientific Press" for May 29, 1909.

each pair of coils. The 1-in. track-cable weighed 1.64 lbs. per running foot, the ⅞-in. track-cable 1.20 lbs. and the ⅝-in. traction, 0.68 lb. The coils were so arranged that each mule-load was about 236 lbs. or 144 ft., of 1-in.; 230 lbs., or 192 ft., of ⅞-in.; 240 lbs., or 354 ft., of ⅝-in. cable. Twelve mules carried the 2,300-ft. length of ¾-in. cable. The largest piece of 1-in. cable required 26 mules for its transport. One man was assigned to each two mules. The mule at the head of the line was controlled by a lead-rope, and each mule's lead-rope was fastened to the pack of the mule in front of it. In this way, they were kept at a uniform pace, and with the men distributed as indicated, the entire train could be stopped simultaneously when necessary to tighten up the cinches, or for other purposes.

The four tube-mills, 20 ft. long × 4 ft. 6 ins. in diameter, were, we believe, the first units of these dimensions and capacity to be sectionalized for mule-back transportation. Each mill is supported on four well-spaced, chrome-steel roller-bearings and the heavy bed-plates to which the bearings are fixed are cut longitudinally and transversely into four sections, two male and two female, the inside and bottom surfaces being finished true and firmly held in position with 1⅛-in. bolts. The locomotive tires were cut vertically into two pieces, each piece being a ring of 5 ft. 3 ins. inside diameter, 2½ ins. thick, and 3 ins. wide, weighing 350 lbs., finished on the inside, bored tapering to fit the packing-rings and held in place with lug-bolts. All packing-rings, flanges and gear-wheel castings were cut in two parts. The steel shell of ⅛-in. plate was cut into three butt-jointed sections, each of which was made in three segments formed to proper radius, with heavy longitudinal butt-straps. The cast-iron flanges holding the shell sections in place were riveted to the shell and bolted together. The tube-mill parts were necessarily quite heavy, and some of them offered a little trouble. Perhaps the most difficult loads to handle were the bearing rollers, not so much because of the weight (385 lbs.), but because they rested high on the *lomillos*—a small wooden crib made of four 4 × 4-in. blocks, which rests on top of the saddle. The locomotive tires were also difficult to handle, and the cast-iron heads, because of their large diameter and frailness, required a man to each mule.

The tanks of the cyanide plant, 18 of which were 30 ft. in diameter and 10 ft. deep, and five were 24 ft. in diameter and 8 ft. deep, offered no mechanical difficulties, but made a large number of plates and an excessive amount of riveting. It was necessary to retain an area not to exceed 17.5 sq. ft. per plate. The maximum size of plates was 5 ft. × 3 ft. 6 ins. Each 30 × 10-ft. tank contained 110 plates, about 50 of ¼-in. thickness at the bottom and 60 of $^{9}/_{16}$-in. on the sides. Besides these there were the top and bottom angle-irons, which were cut into 10 segments each. There were in all about 2,500 plates to handle, and about 175,000 rivets were driven. The line and counter-shafts of the tanks made about 500 ft. in all, varying from 4½-in. diameter down to 3-in., and the greatest length handled was 15 ft. 10 ins. The vertical agitator-shafts, 13 ft. 6 ins. long by $3^{15}/_{16}$-in. diameter, were each taken in one piece weighing 580 lbs. These were carried on picked mules, and two men assigned to each mule, one man ahead with the lead-rope, the other behind to steady the load and prevent it from swinging and see-sawing. Heavy pieces like these were handled in relays, changing mules about every two hours. One of these shafts is shown in Fig. 1.

Friction-clutches (Imperial type) were heavily designed not only to overcome the usual starting load of about 15 HP., but to care for such emergencies as when a careless shiftman allows the density of the charge to reach a point equal to two charges. The heaviest pieces of these clutches weighed 480 lbs. each. The cast-iron crown-wheels, and crosses for agitator-arms were made in four parts, held in place with shrink-rings, bolts and keys. Outside of the crushing-units and power-plant, there were no pieces which gave great trouble. Pumps up to 300 gals. per min., under 180-lb. pressure, as well as centrifugal pumps up to 6-in., and horizontal, straight-line compressors of a capacity up to 400 cu. ft. of free air per minute, can be dismantled without much trouble excepting the bed-plates, which generally require to be specially cast in two or more pieces.

The design of the hydraulic plant kept the individual pieces well within the packing limit, but with the extremely careful workmanship and finish, and the fact that many of the cores were bored for a driving fit-bolt, it was as rigid when assembled as could be asked for. This plant included two double, 26-in. diameter, impulse-wheel units, bed-plates, bearings, shafts, housing, etc., together with 980 ft. of pressure-pipe and 1,500 ft. of grade-piping. Some sections of the ¼-in. gage, 26-in. diameter pressure-pipe, which was furnished in 5-ft. 6-in. lengths, by reason of its weight (396 lbs.), and the 30-in. No. 10 gage grade-pipe, by reason of its bulk, gave some little trouble.

All of the electrical units were assembled and wound at the mine. The 200-KW. generators were housed in skeleton-type frames, cut into two pieces, with short legs bolted to a divided bed-plate. The heaviest part of the generators were the shafts, weighing 520 lbs. each, while in the induction motors the rotors weighed 480 lbs. each, with shaft pressed in.

The fact that the largest stick of timber possible to transport was 10 ins. × 10 ins. × 11 ft. long, and that most of the heavy work was made up of 8-in. × 8-in. × 11-ft. material, necessarily restricted the design of woodwork to certain limits and called for odd spans in order to avoid waste. It also resulted in an enormous amount of splicing, building up, trussing and bracing, besides consuming large quantities of iron in bolts, rods, plates and brackets. The main timber-district is some five hours from the town of Ventanas, at an elevation of about 8,000 ft. above sea-level. A saw-mill of 5M. ft. B. M. daily capacity was put up, and a total of 600M. ft. B. M. of lumber sawed and packed out on burros and mules. The burros handled the lighter stuff, such as 1 × 12-in., 2 × 4-in., and 4 × 4-in. Some 200M ft. B. M. of this lumber was used in flume construction for the hydro-electric plant.

In the timber transport, each mule carried from 88 ft. B. M. (two pieces 6 ins. × 8 ins. × 11 ft.) up to 117 ft. B. M. (two pieces of 8 ins. × 8 ins. × 11 ft.), with the average running about 110 ft. B.M., due to the larger number of 8 × 8-in. pieces handled. The 600M. ft. B. M., therefore, made about 5,500 mule-loads, or 16,500 mule-load days, as the round trip required three days between the saw-mill and Ventanas, and also between the saw-mill and the supply-point for the ditch line, whence it was handled by men. As for weight, two pieces 8 ins. × 8 ins. × 11 ft. would weigh from 350 to 400 lbs., depending on whether it was well seasoned or not, while a few very pitchy sticks which were actually weighed tipped the scales at 620 lbs. for the pair.

In anticipation of the enormous transport job ahead, the first work undertaken was the building and repair-

Fig. 3. A Difficult Load to Balance; Pump Pinion-Shaft with Pulley and Pinion Attached.

ing of about 150 miles of trails. Labor was scarce and was drawn from both the high and low country, but it was not long before it became evident that higher efficiency was obtained, and the cost of accommodations lessened, by separating the coast-men from the mountaineers. At best, the hot-country natives are not overburdened with clothing, and they simply cannot thaw out in the cold climate of the mountains.

Next came the purchase of pack-mules, organization of permanent trail-gangs for repair work, distribution at convenient points of blacksmith outfits and tools, mule shoes, etc. Not of the least importance was the purchase at market rates and distribution of immense quantities of corn and *paja* for mule-feed. The purchase and organization of a large pack-train on company account does not at first suggest economy, but having an intimate knowledge of the Mexican packer or *arriero* and having observed the treachery of the packers as revealed in heavy castings lying on out-of-the-way mountain trails, and having 1,500 tons of heavy, awkward, mining machinery at the railroad terminus, a staff of expensive skilled foreigners and a force of skilled Mexicans at the mine, this course was justified in order to ensure a constant supply of material for the construction gangs, and at the same time to exercise control over the transport rates.

A few Mexican transport-men will take an occasional load of 425 lbs. at absurdly high prices, generally at a figure representing three times the value of the mule; but we had many pieces which were absolutely refused at any price. We have known instances in Mexico in which a company has had a heavy piece of machinery left somewhere along the trail after as much as $125 had been paid for its transportation to the mine. It is customary to advance to packers from 30 to 50% of the total price when starting, and it is not uncommon for them to take half a dozen loads a couple of days out, leave the *carga* scattered along the trail and migrate, if more than one forwarding agent is handling material.

Our next task was perhaps the most difficult of all; to convince our own packers, as well as outsiders, that the intention was to transport this 1,500 tons of heavy, awkward machinery to Ventanas. The more enlightened public, after visits of inspection to the railroad station, held animated discussions to determine who was most destitute of reason, the engineer who undertook the design and erection of the plant or the company that elected to pay for it. The usual day's journey for a pack-mule is from five to six hours, and during the rainy season (June to November in Durango) the animals are generally turned out and allowed to graze on the new sweet grass, which they prefer to the more substantial corn. Consequently they soon lose their strength to such an extent that they cannot stand up under an ordinary load. In this respect, as well as in the matter of the length of *jornada* (daily journey) and the weight of loads, a material departure was made from the usual custom by tying up the mules and feeding them. By reason of slippery trails, heavy loads and "green" mules, we lost, in all, 38 animals during about 16 months of steady work.

The Mexican *aparejo* (pack-saddle) is a large leather bag, divided so as to hang equally over both sides of the mule, and is padded with straw and held in place by heavy breeching and cinches. It covers well the mule's back, and is really better adapted for packs of all weights and dimensions than the pack-saddles of the western United States. When well secured with the diamond hitch thrown by an experienced *arriero*, there is little danger of the load shifting. A good pack-mule *aparejado* (wearing the pack-saddle) is worth from $47 to $65 U. S. currency, and a poor mule is dear at any price. Effective work depends to a great extent upon the selection and assignment of loads, the *arriero* being guided by the gait and build and degree of "mulishness" observed. Some mules will worry themselves into a state of exhaustion with a load that they have made up their minds does not suit them. The amount of intelligence displayed by pack-mules is sometimes marvelous. The affection that is shown for the *yegua* (bell-mare), without which a train cannot be managed, reflects another side of the mule's character, which Mark Twain so aptly described when he said "a mule would make love to its keeper for ten years or more in order to get a chance to kick his head off."

The company's pack-train equipment, comprising about 150 mules, though traveling together, was divided into three trains, each having its separate camp and cooking outfit, saddle-man, cook and force of *arrieros*, with a head-packer in charge of the entire equipment. While, as stated before, the company established supply and storage-stations for corn at convenient points along the route, it was not possible to have these at every stop the trains would make. For this reason, with a 50-mule train, there would be about eight mules carrying corn and camp-equipage. The consumption of corn averaged from four to six liters per day per mule, this being divided into a morning and an evening feed. During the 16 months, the price paid for corn delivered at supply-points was from $5 to $7 per *carga* of two hectoliters. Besides the company's mules, a large number of outside pack-trains were employed, as well as numerous burro-trains carrying the lighter stuff such as cement.

The loads are generally referred to as *carga*, meaning two or more packages weighing up to 150 or 160 lbs. each, and *cuarteo*, a piece which by reason either of weight or bulk can only be handled singly. In selecting the *carga* or *cuarteo* for the mule, or the mule for a given load, in one case the excessive weight would be the predominating factor, in another the bulk, shape of the piece and difficulties of balancing the load on the saddle. For example, in one of the illustrations (Fig. 3) is shown a load consisting of pump pinion-shaft with pulley and pinion attached. Mules which are broken to the *carga* cannot well handle *cuarteos*, and vice versa, because of the difficulty of balancing. We have seen mules which could readily handle a *carga* of 420 lbs. stumble and flounder about and wear themselves out with a *cuarteo* of 250 lbs. Hence it is advisable to select the mules for each class of service.

Mules broken to carry timber are not effective on other work, and so on. A good *arriero* will almost instinctively select the load best suited to the mule and will also balance the load perfectly. If this be not done, many mules will be ruined in short order. It pays to be ready to help the Mexican *arrieros* if you find them in difficulty on the trail, because in trouble they are perfectly willing to sit down for weeks, not valuing time nor appreciating the need of rushing things. One difficult matter in handling such a large number of pieces and packages and so large a variety of parts was to have the material forwarded in the sequence of erection. It was no easy matter to identify a given part, because of the sectionalization. This was largely overcome by painting the pieces, as required, with conspicuous colors.

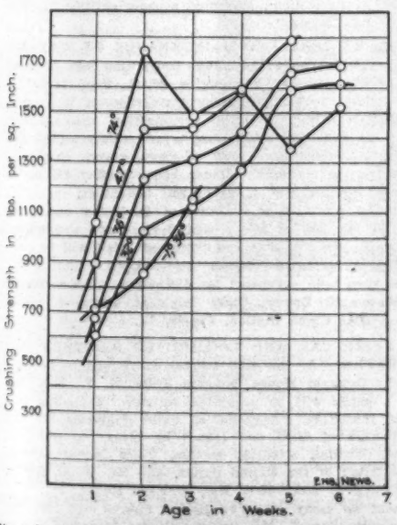
The freight rate for an ordinary *carga* of two pieces, weighing 138 kgs. (304 lbs.) from Durango to Ventanas, fluctuates between $4.25 and $6 per *carga*, or between $29.25 or $42 per metric ton, an approximate average cost of $32.80 per short ton; while, for individual pieces weighing up to 425 lbs., that is, *cuartos*, a special charge of from $10 to $100 is made. The railroad rate from any center in the United States to Durango is $1.60 per 100 lbs., or $32 per short ton. Add to this the local expenses for discharging, transferring, re-packing, etc., (another $2 per ton), and the respectable total of $66 per ton is reached, besides the duties. From Mazatlán the facilities were not so good, but we had only a small part of our stuff to transport from there. The rate from Mazatlán is $1.60 per 100 lbs. and the ocean rate to that port from San Francisco is $5 per ton. There is no reason why San Francisco should not obtain all the West Coast business, particularly now with the Cananea, Rio Yaqui & Pacific branch of the Southern Pacific Railway practically exploiting the interior by way of Guadalajara, freight could be handled by boat to Mazatlán or Manzanillo, and thence by rail to the interior.

About 2,500 tons of material (1,500 tons of machinery, and 1,000 tons of supplies and stores) were transported during a period of 16 months. A small part, as already stated, came by way of Mazatlán. It made 17,500 mule-loads, or 262,500 mule-load days, taking 15 days for the round trip. Out of this lot, but four pieces of castings were broken, one motor-rotor and ten tank-sheets lost (out of 2,500 sheets). Twelve packages or pieces were lost by the railways. There were but two pieces of the plant which were not delivered at Ventanas, namely, the bed-plates, with guides cast on, of a Deane horizontal duplex pump, weighing 720 lbs. each. These were sent by mistake and were taken within 10 hours of Ventanas before the properly sectionalized bed-plates arrived and the mistake was discovered. There they no doubt will remain for a long time as monuments commemorating those gallant mules.

Tests on the Effect of Temperature on the Setting of Concrete.

As an addition to the material being accumulated regarding the effect of temperature on the setting of concrete we abstract below a series of tests carried on the past year as thesis work at Worcester Polytechnic Institute (Massachusetts) by Messrs. R. W. Crowther and L. E. Swift, under the direction of Prof. A. W. French. There are numerous inconsistencies in the results but the general effect of temperature variation is well shown.

The tests were made on 5 × 5 × 12-in. 1:2:4 (by weight) blocks in compression. The aggregate was a well-graded mixture and the cement



Time-Strength Curves of Concrete Blocks Under Various Temperatures.

a standard brand which showed 766 lbs. per sq. in. in tension for 30-day neat briquettes and 281 lbs. per sq. in. for 1:3 mortar briquettes. All blocks were mixed in a room with a uniform temperature of 70° F., using water at 65° F., and the regular interval between the gaging of the concrete and the removal to the setting temperature was 2¼ hours. Forms were kept on the blocks for one week and the entire setting period in all cases was in air.

With the exception of the batch of blocks placed in the 1° F. temperature, each temperature batch consisted of 6 lots, of 3 blocks each, tested at 1, 2, 3, 4, 5 and 6 weeks, respectively. These batches were placed in temperatures of + 32°, + 36°, + 47° and + 74° F., respectively, and broken in compression immediately on removal therefrom. The first batch (— 1° F.) was more complicated. All blocks were placed in a temperature of 1° for varying intervals and some were tested immediately on removal therefrom, while others were placed first in a 2-day 70° temperature and then for varying intervals in a 36° temperature. The outline of these tests, together with the values of crushing tests, are given in Table I.

Table II. gives the averages of each of the other tests and the whole series is graphically shown in the accompanying diagram.

TABLE I.

	Days in storage 1°	70°	36°	Crushing strength, lbs. per sq. in. Each.	Average.
1	7	..	..	817	...
2	7	2	..	0	...
3	7	7	..	908	...
4	14	..	..	337	...
5	14	2	..	0	...
6	14	7	..	723	...
7	21	..	..	647	...
8	21	7	..	912	...
9	21	7	..	906	...
10	26	2	7	726	
11	26	2	7	679	719
12	26	2	7	753	
13	26	2	14	871	
14	26	2	14	950	838
15	26	2	14	754	
16	26	2	21	1,246	
17	26	2	21	952	1,155
18	26	2	21	1,267	

TABLE II.

Age in days.	32° F.	36° F.	47° F.	74° F.
1 week	608	679	897	1,059
2 weeks	1,027	1,232	1,435	1,746
3 weeks	1,127	1,312	1,443	1,491
4 weeks	1,274	1,422	1,587	1,598
5 weeks	1,591	1,662	1,790	1,359
6 weeks	1,617	1,689	....	1,524

A CLOUDBURST IN WEST VIRGINIA, July 29, caused heavy damage to farm property along the Tygart's Valley and Cheat rivers. Many wooden bridges were carried away and the Durbin branch of the Western Maryland R. R. was disabled by the washing out of its track.

A FLOOD IN CHINA during the latter part of July is reported to have submerged 7,000 houses in the city of Kirin, Province of Chang Chun, Manchuria, causing the death of 1,000 people. Kirin is on the Sungari River, 225 miles from Mukden. Traffic on the Antung-Mukden Ry. was entirely suspended.

A STREET RAILWAY CAR at Longjumeau, France, was struck by a vegetable train Aug. 8 while waiting for the removal from the track of a horse whose hoof had been caught in a frog. Twelve passengers were killed and about 25 others were injured.

A HEAD-ON COLLISION between a north and a south-bound passenger train on the Louisville & Nashville R. R., near Galloway, Tenn., Aug. 8, caused the death of one of the engineers and the injury of 20 passengers.

FIRE DESTROYED ONE SPAN OF A BRIDGE across the Delaware River at Trenton, N. J., Aug. 10. The bridge was used until a few years ago by trains on the main line of the Pennsylvania R. R., but, since the completion of the newer railroad bridge, the old one has been used only as a highway bridge.

THE BRITISH STEAMER "MAORI" sank Aug. 5 off the coast of Africa, near Cape Town, and 47 of her crew were drowned. Three of her boats were launched with a total of 55 men but only eight of the men reached the shore alive.

A POWDER MILL EXPLOSION at Wilmington, Del., Aug. 7, wrecked grinding mill No. 8 of the E. I. Du Pont de Nemours Powder Co. and killed the one workman in the building. About 1,000 lbs. of black powder exploded.

THREE MILES OF PIPE LINE BURST near Hadley, Ind., Aug. 7. The line was of 12-in. iron pipe owned by the Indiana Gas & Oil Co. and was laid at a depth of from 2 to 6 ft. below the surface. Workmen were testing the main and, according to reports, had pumped in air at a pressure of 70 lbs. per square inch when the explosion occurred which broke three miles of pipe. The mains of the Indiana Gas & Oil Co. lead from the gas wells in Grant and Howard Counties, Indiana, to Chicago, Ill., and have been in the ground about 15 years.

A HOTEL FIRE AT VERNON, B. C., Aug. 10, resulted in the death of eleven persons. The Okanagan hotel was a three-story, brick-veneered frame building and burned very rapidly. There were 74 guests in the building at the time of the fire, which started early in the morning. Those who lost their lives were cut off from escape by the rapid destruction of the two staircases.

AN AEROPLANE FLIGHT of 2 hrs., 27 min., 15 sec., is the record established by Roger Sommer on Aug. 7, at Mourmelon, France. This surpasses the record by Wilbur Wright of 2 hrs., 20 mins., 57 sec., at Le Mans, France, in December, 1908. Sommer's flyer was designed by Henry Farman, once a holder of the endurance-flight record, and is on the general lines of the Wright machines. There was nothing remarkable about the flight itself.

PANAMA CANAL EXCAVATION during July totaled 2,843,260 cu. yds. for 26 working days, a daily average of 109,356 cu. yds. The rainfall was 10.66 ins. During the month 8,156 cu. yds. of concrete was laid and 558,401 cu. yds. of fill placed in dams.

THE POLLUTION OF RIVERS and the means of attacking the problem of their purification have been taken up by the Fishing Club of France, according to a letter from that club to "La Technique Sanitaire" of Paris, in which the club announces that it will offer a prize for a report on the cheapest and most practical means of purifying the residual water from paper factories, at the same time utilizing the maximum amount of wood pulp.

A PASSENGER TRAIN STRUCK A STREET-CAR at the Pennsylvania R. R. grade crossing on Indianapolis Ave., near 103d St., South Chicago, Ill., Aug. 5. The conductor of the electric car, which was bound from Whiting, Ind., to South Chicago, was killed and all of the 50 or more passengers were injured. No flagman nor gates are provided at this crossing, which is situated at a curve in the Pennsylvania tracks, which has earned the title of "death curve." The train was running at a speed of about 20 mi. per hr. when it struck the car. The accident is ascribed to carelessness on the part of the street car conductor. He had stepped onto the crossing in advance of his car in order to look for approaching trains and is reported to have signalled his motorman to go ahead after looking in only one direction along the railway track.

ILLUMINATION OF NEW YORK CITY, for the Hudson-Fulton celebration in October, has been planned on an enormous scale and in an elaborate way. It is announced that some 1,500,000 additional incandescent lamps, 10,000 arcs and two batteries of search-lights will be used. This gives a total of about 26,260,000 c. p. in addition to that from any electric signs that the merchants may erect about Manhattan. This illumination will be made under the direction of the Hudson-Fulton celebration commission which will pay for a considerable part.

The batteries of searchlights will be placed in the vicinity of Riverside Drive, on the Hudson River at 110th St. Important buildings and monuments will be lighted and routes of the numerous parades will be lined with festoons of lamps. A string of about 20 huge signal fires, along the Hudson to Newburg, will be lighted on Oct. 9, "Illumination Night."

A SEWAGE DISPOSAL CONFERENCE, embracing various cities and towns in the Mahoning Valley, was held on Aug. 5 at Warren. The towns in this valley include Youngstown, Warren, Niles, Alliance and others. About a hundred representatives were present at the conference. A report on investigations of the effect of manufacturing wastes and town sewage pollution upon the waters of the Mahoning River was presented to the conference by engineers of the State Board of Health. The investigation had extended over two years. The report included outlines of various projects for water and sewage purification by some of the towns. The conference led to no specific action on the part of the hundred or so representatives of the various towns present, but it is expected that further conferences will be held and that perhaps some of the towns may unite in concerted action. One of these plans for concerted action is that of the city of Youngstown for the building of storage dams to regulate the flow of the river. Such storage dams, it is believed, would benefit Warren, Niles, Girard and Struthers, and thus warrant their cooperation at

Youngstown in building the dams. During the conference an address was delivered by Mr. Alexander Potter, Assoc. M. Am. Soc. C. E., of New York City. Mr. Potter laid stress upon the need of more extended recognition of the fact that the establishment of sewage treatment works should be regarded as a means of preventing general nuisance rather than as for the protection of public water-supplies. The propriety of sewage disposal by dilution when circumstances favor it was affirmed. Mr. Potter also urged that state boards of health should not be too didactic in their instructions to municipalities regarding the methods to be employed in treating sewage or water, and that it should be expected that municipalities should have a considerable degree of freedom in deciding just what plan of treatment was best suited to local conditions. This, he urged, the municipalities are better able to decide than the state, inasmuch as the city can go much farther into investigations than it is possible for the state to do.

TREE PLANTING ON MASSACHUSETTS ROADS is reported on by Mr. E. W. Breed, Forester of the State Highway Commission in the report of the commission for the year 1907-8. During the year ending Nov. 30, 1,184 new trees were planted and 744 trees formerly planted were replaced. The total number of trees planted in five years ending with the date named was 13,113, distributed among 55 towns. The cost of planting new trees in 1908 averaged $1.29 each, and the cost of maintenance for the same year was 20 cts. per tree. An average of 49 cts. each was expended in preparing ground for 733 trees.

Personals.

Mr. Hugh Haddow, Jr., has been appointed Chief Engineer of the New Orleans Great Northern R. R., with office at Bogalusa, La.

Mr. John A. Bohland has been appointed Bridge Engineer of the Great Northern Ry. to succeed George A. Casseday, whose death was noted in this column July 29.

Mr. Joseph Walker has been promoted to be Master Mechanic of the Illinois Central R. R. shops at East St. Louis, Ill., to succeed Mr. W. McIntosh, transferred to Memphis, Tenn.

Mr. Oscar L. Young, of Laconia, N. H., has been appointed to fill the vacancy in the New Hampshire State Railway Commission caused by the death of Henry M. Putney, noted in our issue of Aug. 5.

Mr. J. A. Gearhart has severed his connection with the Pennsylvania R. R. Co., as Material Inspector in charge of the Pittsburg district, and has become Manager of the inspection department of the Gulick-Henderson Co., 439 Third Ave., Pittsburg, Pa.

Mr. F. S. James has been appointed Superintendent of the second division of the Denver & Rio Grande R. R., with headquarters at Salida, Colo. Mr. P. B. McAtee, who has been Acting Superintendent of the fourth division, has been given full title.

Mr. W. G. Arn, Assoc. M. Am. Soc. C. E., recently Assistant Engineer of the Birmingham division of the Illinois Central R. R., has been made Assistant Engineer in charge of improvements to be made by that railroad in New Orleans, La., and vicinity.

Mr. E. H. Fish has resigned his position as instructor in mechanical engineering at the Worcester Polytechnic Institute to become Director of the Worcester Trade School. An article by Mr. Fish on "The Worcester Trade School Plan" was published in Engineering News, Nov. 26, 1908.

Mr. A. F. Bannon, Jr., former City Engineer of Bradford, Pa., has become Superintendent of Public Works at Hornell, N. Y., succeeding Frederic Leach, deceased. Mr. Bannon is succeeded as City Engineer of Bradford, Pa., by Mr. B. A. Wise, who has been Assistant Engineer for several years.

Mr. James W. Callahan, General Superintendent of the Illinois Tunnel Co., Chicago, Ill., has become General Manager to succeed Mr. W. J. C. Kenyon, resigned. The position of general superintendent is abolished and the office of vice-president, which was held by Mr. Kenyon, will not be filled for the present.

Mr. Edward W. Bush, M. Am. Soc. C. E., has been appointed Chief Engineer of the bridge to be built near the mouth of the Connecticut River joining Old Lyme and Old Saybrook, Conn. Mr. Bush was employed as an engineer on the Hartford Bridge during the last few years of its construction and has been for some time Assistant Engineer of the Connecticut River Bridge and Highway District Commission. He was graduated in civil engineering at the Pennsylvania State College in the class of 1892.

Mr. Charles M. Jacobs, M. Am. Soc. C. E., has resigned his position as Chief Engineer of the North River division of the Pennsylvania Tunnel & Terminal R. R. and sailed for Europe Aug. 5. The work under his direction on the North River and Bergen Hill tunnels has been practically completed. Mr. James Forgie, who has been Mr. Jacobs' chief assistant, remains in charge of the completion of unfinished details. Having disposed of the problems it was organized to consider in connection with the Pennsylvania Tunnel, the advisory board of engineers of which Mr. Jacobs was a member has been dissolved. The other members of this board were Gen. Charles W. Raymond, M. Am. Soc. C. E., Chairman; Mr. Alfred Noble, Past President, Am. Soc. C. E., and Mr. George Gibbs, M. Am. Soc. C. E.

Obituary.

Joseph W. Thompson, inventor of the Thompson indicator and originator of the valve gear of the Buckeye automatic high speed engine, died July 15 at his home in Salem, Ohio. Mr. Thompson was born in Columbiana Co., Ohio, in 1833.

Calvin Wells, President of the Illinois Zinc Co., Peru, Ill., and of the Pittsburg Forge & Iron Co. for more than 30 years, died Aug. 2 at his home in Pittsburg, Pa., aged 82 years. Mr. Wells was born in Genesee Co., N. Y., and was educated at the Western University of Pennsylvania.

Charles McIlvaine, who was a division engineer of the Brandywine & Waynesburg Ry. in 1861, died Aug. 4 at his home in Cleft Bank, Md., at the age of 69 years. Capt. McIlvaine gave up his work at the opening of the Civil War to organize a volunteer company, which became Company N, of the 97th Regiment of Pennsylvania Volunteers.

Patrick J. Brennan, President of the Brennan Construction Co., Washington, D. C., died Aug. 10 at his country home in Hyattsville, Md., aged 38 years. His death was the result of his being thrown from his automobile about two weeks before by a collision with a buggy. Mr. Brennan was born in Galloway, Ireland, and came to this country with his parents in 1882.

Charles M. Bissell, formerly Commissioner of Public Works in Albany, N. Y., died Aug. 5 at Gloucester, Mass. Mr. Bissell was born in Rensselaer Co., N. Y. Previously to his appointment as Commissioner of Public Works in 1900, the greater part of his life was spent in railway service. He began as a switchman on the Troy & Boston R. R., and in 1888 became Superintendent of the Eastern division of the New York Central & Hudson River R. R. He resigned this position in 1891 to engage in manufacturing, but later returned to railroading as General Manager of the Findlay, Ft. Wayne & Western R. R. He served as Commissioner of Public Works in Albany from 1900 to 1907, when he was appointed Fiscal Supervisor of State Charities, which position he continued to hold up to the time of his death.

Arthur E. Welby, First Vice-President and General Manager of the Denver, Laramie & Northwestern R. R., died Aug 9 at Denver, Colo. Mr. Welby was born at Georgetown, South Africa, in 1855. He entered railway service as a rodman on the Great Western Ry. of Canada (now the Grand Trunk Ry.) in 1872. He remained with the Grand Trunk Ry. in various capacities until in 1883 he became clerk to one of the division superintendents of the Denver & Rio Grande R. R. In 1890 he became Superintendent of the Rio Grande Western Ry. and was made General Superintendent of that railway two years later. From 1902 to '04 he was General Manager of the Cerro de Pasco Ry. in Peru, but returned in December, 1904, to his former position with the Rio Grande Western. Mr. Welby was appointed Vice-President and General Manager of the Denver, Laramie & Northwestern R. R. in October, 1908, and held this position up to the time of his death.

Christopher P. Brooks, a professor of textile manufacturing and the organizer of four textile schools, died Aug. 2 at St. Anne's-on-the-Sea, Lancashire, England. He was born in Blackburn, Eng., in 1866, and came to this country when about 30 years old. Before leaving England, he organized the textile department of the Blackburn Science and Technical Schools, in 1884, and, from 1886 to 1895, was superintendent and managing director of English cotton mills. From 1890 to '95, he was Examiner in Cotton Manufacturing in all English technical schools. After coming to the United States, he organized, in 1896, the Lowell (Mass.) Textile School, and two years later organized the New Bedford (Mass.) Textile School, of which he was Managing Director until 1904. He established the American Correspondence School of Textiles in 1898. Mr. Brooks was a member of the National Association of Cotton Manufacturers and the International Congress of Technical Education, and was the author of numerous books and articles on textiles and textile manufacturing.

Engineering Societies.

COMING MEETINGS.

LEAGUE OF AMERICAN MUNICIPALITIES.
Aug. 25-27. Annual convention at Montreal, Can. Secy., John MacVicar, Des Moines, Iowa.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Aug. 31-Sept. 2. Annual meeting at Briarcliff Manor, N. Y. Secy., D. L. Huntington, Spokane, Wash.

TRAVELING ENGINEERS' ASSOCIATION.
Sept. 7-10. Annual convention at Denver, Colo. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 8-10. Annual convention at New York City. Secy., Willard Kent, 715 Tremont Temple, Boston, Mass.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 14-16. Annual convention at Atlantic City, N. J. Secy., Frank P. Foster, Corning, N. Y.

MICHIGAN GAS ASSOCIATION.
Sept. 14-17. Annual meeting on board steamer sailing from Detroit, Mich. Secy., A. P. Ewing, Gas Office Bldg., Detroit, Mich.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION.
Sept. 14-17. Annual convention at Washington, D. C. Secy., Walter E. Emery, Peoria & Pekin Union Ry., Peoria, Ill.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 14-17. Annual convention at Niagara Falls, N. Y. Secy., A. P. Dane, Boston & Maine R. R., Reading, Mass.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Sept. 16-Oct. 12. Annual convention and excursion on special train starting at Chicago, Ill. Secy., R. W. Raymond, 29 W. 39th St., New York City.

AMERICAN STREET & INTERURBAN RAILWAY ASSOCIATION.
Oct. 4-8. Annual convention at Denver, Colo. Secy., Bernard V. Swenson, 29 W. 39th St., New York City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 12-14. Annual convention at Louisville, Ky. Secy., C. C. Rosenberg, Bethlehem, Pa.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 19. Annual convention at Jacksonville, Fla. Secy., S. F. Patterson, Boston & Maine R. R., Concord, N. H.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Oct. 19-22. Annual convention at Richmond, Va. Secy., Chas. O. Probst, Columbus, Ohio.

AMERICAN GAS INSTITUTE.
Oct. 20. Annual meeting at Detroit, Mich. Secy., A. B. Beadle, 29 W. 39th St., New York City.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.—The summer meeting will be held Aug. 17 at Stoney Creek and the Thimble Islands, Connecticut. Mr. J. Frederick Jackson, New Haven, Conn., is the secretary.

DEEP WATERWAYS ASSOCIATION.—The second annual convention will be held Oct. 19-22, in Norfolk, Va. The development of inland waterways paralleling the Atlantic coast from Maine to Florida is announced as the chief aim of this society.

SOCIETY OF AUTOMOBILE ENGINEERS.—The summer meeting was held in Chicago, Ill., Aug. 5-7. Papers on electric vehicle and battery construction were presented by Harold M. Beck, Chicago, Ill.; Alex. Churchward, New York City; Robt. McAllester Lloyd, Long Island City, N. Y.; Edward Lunn, Chicago, Ill., and Dr. Sokal, Chicago, Ill. H. S. Baldwin, Lynn, Mass., and R. C. Carpenter, Ithaca, N. Y., presented papers on gasoline motors and testing apparatus, and Frank Harris Floyd, Detroit, Mich., presented a paper entitled "Lubricants and Testing."

ROADMASTERS AND MAINTENANCE OF WAY ASSOCIATION.—The 27th annual convention will be held at the Ebbitt Hotel, Washington, D. C., Sept. 14 to 17. The following committee reports are expected to be presented: (1) relaying rails; organization, methods and cost; (2) standard switch targets and safety switch devices; (3) comparative value of stone, gravel, chats and burnt gumbo for ballast under heavy traffic; (4) cattle guards; (5) different kinds of rail fastenings, including insulated joints; (6) varieties of tie-plates and their merits; (7) new and improved devices and appliances, including ties. A paper on "Treated Ties" will be presented by Mr. J. M. Meade, and several topical questions have been suggested for discussion. The secretary is Walter E. Emery, Chief Engineer, Peoria & Pekin Union Ry., Union Station, Peoria, Ill.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.—At the 40th annual convention to be held in the Cataract House, Niagara Falls, N. Y., Sept. 14-17, a paper will be presented entitled "Excluding and Rust Inhibiting Properties of Paint Pigments for the Protection of Steel and Iron," by Henry A. Gardner, Chief Chemist, scientific section, Paint Manufacturers' Association of the United States, and Mr. W. O. Quest, Pittsburg & Lake Erie Ry., McKees Rocks, Pa., will present an essay on "The Master Painter and the Materials He Uses." Mr. Quest will also present a report as Chairman of the committee on tests. The best method of painting new steel passenger cars and of maintaining the same will be discussed by Messrs. H. C. Lafferty, Standard Steel Co., New Castle, Pa.; Wm. A. Breithaupt, Pullman Co., Chicago, Ill., and C. C. Abel, American Car & Foundry Co., Berwick, Pa. Among the other subjects to be discussed are the use of cork, or other materials, as a preventative of moisture or dampness in the finishing of steel passenger cars; the maintenance of passenger car floors and the best method of treating and maintaining the interior of old and new refrigerator cars.